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THE WAY LIFE BEGINS

Sphinx Moths Gathering Nectar from the Lily Flower
(PLATE I)

THE WAY LIFE BEGINS

An Introduction to Sex Education

TEXT AND ILLUSTRATIONS

BY

BERTHA CHAPMAN CADY

AND

VERNON MOSHER CADY

WITH FOREWORD

BY

WILLIAM FREEMAN SNOW, M.D.

Published by

THE AMERICAN SOCIAL HYGIENE ASSOCIATION

105 WEST 40TH STREET

NEW YORK

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The American Social Hygiene Association

SERIAL PUBLICATION NO. 85

Douglas C. McMurtrie New York

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FOREWORD

Many requests have been received by the American Social Hygiene Association from parents and teachers, for help in dealing with the various problems of sex education. The inquiries take the form of specific questions or of requests for books to be recommended for particular purposes. In the effort to meet the needs of both parents and teachers the Association, as a part of its educational work, has prepared numerous exhibits, held parents' and teachers' conferences, published leaflets, and replied to a large number of personal applications for advice and information. The Association has also conducted many careful experiments to determine the books and other helps which would be most useful to parents and teachers in their educational work.

Out of this experience has come the realization that there exists a genuine demand for a simple, scientifically accurate book on the subject of the way plant, animal, and human life begins, written in an interesting, non-technical way, and with adequate illustration.

Whether the authors and the Association, in acting as the publisher of this book, have made a real contribution to sex education literature, the reader will best judge. The book tells the truth about reproduction, with regard for its moral significance, seeing in reproduction, both of human beings and of animals, one of the most interesting stories in the world—a story that every youth should learn from competent persons.

The opinions and suggestions of readers upon ways in which the book may be effectively used or changes which should be considered in any future edition, will be welcomed by the Association and the authors.

Dealing as it does with a fundamental phase of sex education, this book forms a fitting introduction to a series of

inexpensive books which the Association has been urged to publish, from time to time, relating to other important topics in the field of social hygiene.

WILLIAM F. SNOW, M.D.,
General Secretary,
The American Social Hygiene Association

105 West 40th Street
New York City

AUTHORS' NOTE

In sending out this little book, written more expressly for parents and teachers, the authors have had a threefold object in mind. First, the need of a statement of the fundamental facts concerning the reproduction of living forms; second, the interpretation of these facts in terms of human interest and well being; third, to call to mind the truth that neither nature nor all that she can come to mean to us is the whole story of the heart and mind of man.

The truth about nature, with all that science has brought us, is not easy to put in intelligible form, even for the earnest reader; moreover it would seem that extreme simplicity of statement, in such an involved subject as that of sex, must be sacrificed, in a measure, to accuracy of statement. This is not to say, however, that children do not grasp big truths when they are adequately expressed in simple language. But those who would undertake to teach must possess a larger fund of information than may be for the moment required to answer the child's question, in order that his interest may be awakened and sustained. It has been our hope to so state the facts that the reader also will desire to go farther into a field the full exploration of which requires the best abilities of mankind.

One frequently hears the remark that knowledge of itself is worthless to make good conduct, or, indeed, to make life worth while. The truth behind this opinion must be that knowledge is impotent until it has served, or proposes to serve, some human good. That nature-knowledge can make major contributions to life we have tried to show in the chapter on 'The Deeper Meaning of Nature Study', and that on 'Nature Study and the Personal Problems of Life'. This effort to bring nature into line with life means, of course, that inferences of various kinds suitable to our needs are being drawn from the facts as they are presented us by observation and by science. The liability of error here is

very great; we do not escape the harm that may be thus caused, however, by denying ourselves the rich reward of discovering the facts of nature and of seeing in them human meanings. To dwell only upon facts impoverishes the spirit, makes for a false and mechanistic materialism, and, as has so often been said, contributes nothing to the moral life. They may even enable their possessor to defeat his own moral interests and those of his fellows.

Many say that nature facts and their meanings are insufficient; that sex education must draw its inspiration, and not a little of its guidance, from religion. Nothing that we have said in this book can be taken as a denial of this claim. Men lived the best of lives long before much was known about nature, and they will continue to do so without much regard to the workings of natural law. We should not be committed to a decision of which is the greater authority, soul or nature. For aught we know the two are the same. If there is any merit in this book it will lie in the fact that priority is not claimed for the 'facts', the 'laws', or the 'principles' of nature, or of their interpretation in terms of the things for which we most care, or, again, for the regulative powers of religion and ethical ideals. Must we be charged with contradiction, however, when we assert that we should go to nature not to get support and justification for sex education, but rather in and for herself? Our conclusion is that men live best when they neither deny themselves the verdict of the head nor the intimations of the heart, but seek a working harmony of both.

If this book contributes even a small share in making the task an easier one for the many earnest teachers and parents who to-day are facing the problem of sex education, our efforts shall have been well repaid.

Our readers, as well as we ourselves, are indebted to a number of educators, physicians, and others interested in the social hygiene movement, who have contributed generously of their time to the reading and criticism of the manuscript.

THE AUTHORS

New York

THE DEEPER MEANING OF NATURE STUDY

This generation is rich, above all others, in its possession of nature-knowledge. Until the last hundred years or so a few people, perhaps, were familiar with the habits of some of the plants and animals, but for the most part living things were thought of as mere entities of the forest, field, and garden. Familiar things were disregarded, while unfamiliar plants and animals were looked upon as curiosities of creation, existing for no good purpose; or, as obnoxious excrescences upon the otherwise peaceful face of the earth. There are still many people who share this old-time thought that the sub-human life of the world is not worthy of consideration unless it serves some obviously human end.

Thanks to our accumulated nature-knowledge, we now must and gladly do take another view of the lowly inhabitants of the earth. We now know that each and every living creature has a life story, and we have become profoundly aware that, after all, these life stories, when they are told, are not so different from our own. There is, indeed, a web of life, and we and all other growing things that are born, live, and die, are weaving a part of it. Some of the patterns of the web are small, and some are large. The fabric of life now sweeps up to high places, and now sinks to low; but the fibres of the mesh pass through all, and bind all in one compelling whole.

To some people this view is disconcerting. They are not able to see the kinship of plants with animals, or of animals with mankind. They may admit that there is a web of life, but to them there are three such webs, one for each of three great kingdoms of plants, animals, and mankind. But increasing nature-knowledge, while it may deepen the mysteries of life, does assuredly bind more closely the seemingly independent divisions of the living world.

The Community of Human and Animal Life

With the new nature-knowledge has come a new pleasure, an enriched feeling in observing plants and in associating

with animals. Knowledge has made clear the struggle and the not infrequent tragedy of their lives and has given an insight into the fact that, to them as to us, even though perhaps unconsciously, life is dear, and is purchased only at much cost. For mankind, the bringing forth and rearing of young means sacrifice; but for animals it means that all else is subordinated to this end. This knowledge has brought sympathy, and has forced us to see that animals have a life purpose of their own; and that if they are of no use to us, they are of use to themselves, and are not wantonly to be destroyed.

Many people, strangely enough, cannot see the so-called moral and spiritual meaning in the lives of plants and animals. Their attention is drawn so fully to the minor habits and differences that set animals off from human conventions, that the real character of their lives is not seen. On the other hand, it is often not apparent to those who believe in the essential superiority of man that when he acts in masses his conduct is apt to be mechanical, unreasoning, and often unworthy of his higher endowments.

The Redemption of the Sex Idea

When we attempt to understand, even in a limited way, the part that sex plays in our life, its potentialities for good and the share that it has had in the history of life on earth, we are not apt to turn in disgust from its normal expression. Instead of seeing in its evil manifestations a proof of its innate degradation, we are led to acknowledge that these are but perversions of something originally good.

There is, however, one aspect of sex which, for human beings, brings an unending train of misfortune. This is man's capacity to exaggerate and pervert the instinct of reproduction. If we charge nature with the evil consequences of this impulse, we have not understood how difficult it has been to make certain of animal reproduction without offering a strong motive; or, in the case of human beings with memory, to get them to undergo the danger and to make the sacrifice associated with procreation. Even to this day the desire for

children, or for any family life, apart from the pleasures of sex relationships, is frequently not sufficient to insure human reproduction.

There is no evidence that nature is interested in the sexual instinct of animals as an end in itself, or in its erotic manifestation in human life. Reproduction is the purpose in view, so to speak, and instinct in animals, and instinct with its associated pleasurable emotion in man seem but nature's means of bringing about this end. In the human female, the love for the child and for the family has gained great headway over the sexual impulse. The same is true of the modern man as compared with his less civilized brother. No doubt nature would sanction the displacement of the sexual impulse by the family instinct if the latter were the more effective means of maintaining the race. Probably the impulse now has and for a long time to come will have its legitimate work to do; moreover we should not repudiate the agent that has brought us so far. Then, too, sex emotion and love emotion, like two miscible solutions, blend and interpenetrate one with the other. With the right psychic soil, to change the figure, the sex instinct proves the germinating seed out of which grows the human qualities and associations most prized, namely, love, marriage, home, father, mother, love for the child, filial and paternal devotion, and from these a social system.

Neither are we to condemn nature because man has employed his intellect and will to split asunder the natural sequence of sex impulse and reproduction, appropriating the pleasures of the former, while rejecting the hardships of the latter.

There need be no redemption of sex as it is found in nature, therefore, or, indeed, in human life; there is need, however, for the redemption of our idea of sex.

The Study of Plants and Animals Without Reference to Sex or Reproduction

A nature study that includes the whole economy and life story of the animal, or, indeed, of man, cannot, if it is thorough and sincere, ignore the place sex occupies in life. There

need be no fear that a force which is so enormous and all-inclusive is therefore necessarily baneful. Those who are firmly convinced that sex is evil or degraded will either not tolerate any study of nature, or will accept only an emasculated form from which all direct reference to sex is eliminated. Our nature books, almost without exception, fulfil this last requirement; they provide most elaborate studies of animal life without reference to one of the chief objects for which animals live. Since there are so many studies of this kind available, the following stories of the lily, the moth, the fish, the frog, the chick, the rabbit, and the child, emphasize especially the reproductive side of their lives, with the hope, however, that this information will be fully related, by those who use it, to the rest of the structure and activities of these living forms.

Unpreparedness of Parents and Teachers

City bred children do not have the opportunities afforded the country child for observation of animals; therefore it is most important that information concerning reproduction be given them. This is, however, a form of biological information which parents and teachers are often least able to give. Their unpreparedness for this task is due, not so much to the unnatural embarrassment which is sometimes made to surround the subject, or to a deliberate attempt to preserve ignorance in the interest of virtue, as it is a need of the necessary information. When one is unacquainted with the ordinary daily habits of plants and animals and their internal structure, it is not easy to form a clear idea of their very intricate processes of reproduction. The best preparation for understanding these processes, and, therefore, the ability to explain them to others, is to obtain a mastery of the life-history of some one plant or animal.

When plants and animals are studied in this earnest way, with a frank desire to know as much as possible about them, there is no occasion for embarrassment or reticence on the part of teacher or pupil, parent or child, when dealing with their sex habits or the structure of the sex organs. The teacher

or parent may feel that success has been achieved when a child or adolescent looks upon the facts of reproduction, wherever they are found, as no less mysterious, wonderful, or beautiful than other facts of life. If children gradually acquire this mental attitude, they will be proof against the brooding mystery, the soliciting and haunting curiosity with which the subject of sex is now too frequently surrounded.

Begin With a Few Plants and Animals

Any common plant or animal whose life activities and structures are understood, will furnish much of the needed material for one's own study, and an object lesson for teaching. Books may be consulted and used as helps, but they will not take the place of observation and familiarity through long-continued association with the living form. The beginner might well confine his attention to one plant or animal until he has at least learned the more common facts of its life habits, environment, reproductive cycle, and its relations to other organisms. The matured nature student will, of course, be able to use any material that comes to hand, or to answer satisfactorily any reasonable question that a child may ask.

The study of a few typical plants or animals will not be difficult. The good teacher will always compare the structures and functions of diverse forms one with the other, so that what has already been learned shall still further explain and co-ordinate the new. In all such studies it will be found that the same plan, the same structure, is endlessly repeated in great groups of plants and animals.

Nature Study Pays Good Dividends

Nature-knowledge, even when acquired at some cost, pays good dividends. Rightly directed, it disciplines the memory and stimulates the reasoning powers. It humanizes and tempers the brutalizing tendency in youth; it makes clear the enduring relation of parents and young, and the racial meaning of mother love. It gives the mind a glimpse of the web of life, and furnishes a bulwark against superstition and surmise. In matters of sex, it proves, to any reasoning mind,

that the frequent exercise of the sexual function on the part of the human male is not a God-commanded right. Indeed, it is not too much to believe that children who have had the benefit of an uncensored knowledge of nature will, when grown, be less inclined to set aside the moral laws of family and society, than those who have been denied the satisfaction of a natural and normal curiosity. It is not merely facts as such that may be expected to work this transformation, but the wider sympathies and the better understanding of the natural order that follows upon their presentation. Nature, after all, is rather conservative and slow moving, offering little sanction for human haste and fret, and still less for the vices of mankind.

Keeping Close to Nature

Over half of the people of this country are now living in cities and towns, preoccupied with intricate, and as compared with their ancestors, artificial and non-natural activities. City people, however, cannot afford to sever their connection with the natural world. Social life does not alter the fact that mankind shares with the animal the really vital processes of birth, growth, eating, sleeping, learning, reproduction, and death. That we use tools, have a measure of control over our activities, and better means of communication, are not sufficient to set us apart from the rest of the living world.

But even in the city, protected as we are, we do not escape the practical need for nature-knowledge. At bottom, all measures of health and sanitation are based upon biologic fact. Nature study helps us to understand, and, therefore, to conform to the rationale of hygiene: mental, moral, and physical. Beyond all, and very highly to be prized, nature study supplies a continuing occupation—something greatly needed when a disintegrating idleness or an aimless activity frequently fills so much of the leisure time between labor and rest.

THE LILY

It is not a little difficult to think of plants as living beings. They seem so stationary in their positions, their movements so dependent upon external agents, and their various organs and structures so unlike anything we know among animals and human beings, that they seem to belong to the inanimate earth rather than to the living world. Yet plants struggle for their existence just as animals do and exhibit quite as wonderful ways of changing their forms and habits in doing so. They breathe, eat, and drink, protect themselves from enemies, and provide for the union of the sexes and the future care of offspring in ways that would do credit to beings possessed of intelligence.

Plants have a real Purpose in Life

The great underlying purpose of every living creature on the earth, as soon as it can make certain of its own existence, is to reproduce itself and thus provide for the next generation. Plants are no exception to the rule.

After the higher or flowering plant has established itself and succeeded in getting proper food, light, air, and protection, it develops its blossoms. They come late in the life story and are in themselves the center of the life purpose. Their bright colors and their nectar are merely means of realizing this purpose, namely, the preparation of new seed plants. To accomplish this a special set of organs is necessary and it is here that we encounter the fundamental character of sex, much as we find it everywhere among the animals and, indeed, in man. There is an organ to produce the eggs which later nourishes and protects the young. There is also another organ to produce the sperm cells. In the plant the two organs may be in the same flower structure, or in different structures, or, again, they may be borne on different plants.

The Examination of a Flower

Choose a flower and examine it carefully; any of the fruit blossoms, the wild rose, buttercups, snapdragons, geraniums, or mustard will do. The easter lily is selected for description here as the blossom is large and the parts easily seen. The four principal structures of the lily blossom are shown in Figure 1. These are first, the sepals (greenish white); second, the petals; third, the stamens, consisting of the anthers and

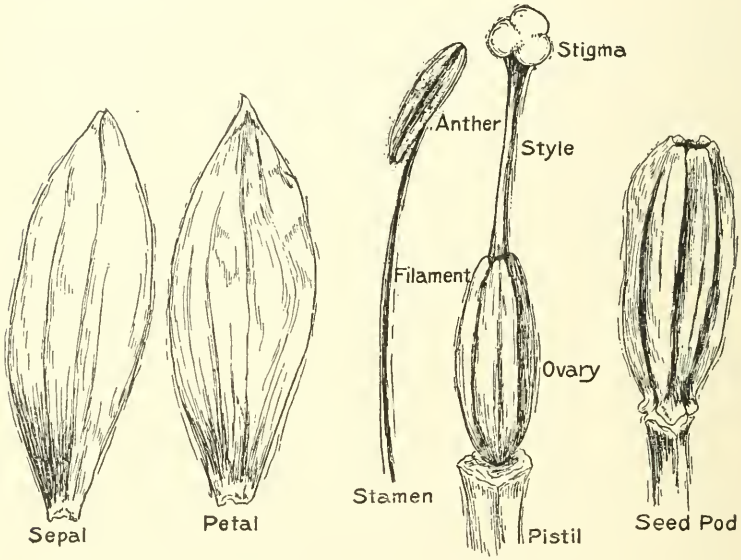


FIGURE 1

The cup of the lily is formed of six white leaves, three sepals and three petals. There are six stamens with their pendant anthers; and one pistil with its three-lobed stigma and ovary. The ripe ovary later becomes the seed pod.

their supporting filaments; and, fourth, the pistil composed of the ovary, the style, and the stigma. These are practically all of the part of the flower which it will be necessary to learn. Taking the lily flower as a whole, there are three sepals and three petals arranged alternately and so forming the flower cup; six stamens; and the three-lobed ovary and stigma. Among flowers there will be found great variability in the form and

number of the sepals and petals; the stamens and pistil may also be greatly increased in number. The 'flower', as we commonly use the word, includes the four types of structure seen in Figure 1, the stamens and the pistil being, however, the essential organs for producing the new generation.

The Easter Lily

Let us now examine the flower-cup of the lily somewhat more closely. (Plate I, frontispiece.) In looking into the lily cup, the bright yellow anthers at once attract our attention. The six anthers, we note, are supported on their long slender filaments. Each anther produces and stores pollen in large quantities. When the anther sac is full of pollen, it bursts and discharges its contents. The nature of the pollen grains or sperm cells and what becomes of them will be discussed later.

Turning next to the pistil, we find it enlarged at the bottom of the flower-cup in such a manner as to form the three-chambered, elongated ovary. Within these chambers are found many bodies called ovules, arranged along their inner walls. Each ovule is attached to the side of the chamber of the ovary by a tiny stem through which it receives its nourishment. Within the ovule is found the egg of the plant, the ovule acting as a protecting envelop. From the top of the ovary rises a slender tube, the style, and at the upper end of the style, lifted far out of the lily vase and above the stamens, is the three-lobed stigma. The stigma is greenish in color, and its surface is covered with a sticky secretion.

The Sphinx Moth and the Easter Lily

We have seen that the pollen, when ripe, is shed by the anthers, and that the eggs of the ovary are in the same flower-cup. Since it is necessary that a sperm cell reach the egg in order that a new plant may be produced, it would seem a simple matter, in the case of the lily, for the sperm to find their way to the eggs of the same flower. Such an event is amply provided against by the greater length of the style and by insect visitors, the sphinx moths, which carry the pollen of one plant to the stigma of another.

The easter lily, like many other luminous white flowers, depends largely upon night flying moths to bear its pollen. White flowers are easily seen in the twilight, especially when they grow close together. Night bloomers like the lily reserve their fragrance and their abundant nectar flow for the night hours, when the swiftly flying, long-tongued moths are about. (Plate I.)

The dusky moth, eager to reach the ring of nectar hidden at the base of the pistil, drives straight into the flower. The pistil, reaching far out of the cup, is sure to strike against the moth as it enters. Coming, pollen-laden from a visit to a nearby lily blossom, the moth rubs the pollen from its furry shoulders against the sticky surface of the stigma. Pushing forward into the narrow flower-cup, the moth crowds against the anthers, yellow with their masses of ripe pollen. The moth, having taken its toll of nectar, whirls away to another lily.

What is meant by Fertilization

So much for the pollen bearers. In order to follow the further history of the pollen after its deposit upon the stigma, we shall have to turn to the microscope. The pollen grain that has found its way to the stigma soon begins to absorb moisture from its surface. It swells to bursting and a tube extends from the pollen grain down through the loose tissue of the style. The tube moves forward until it works its way into the ovary and through the tissues of the ovary to the ovule or egg case. Entrance is made to the ovule through a small opening, the micropyle. The tip of the tube now breaks and frees two or more nuclei. The first is the tube nucleus which has been at the growing point of the tube in its long journey. The other two are sperm nuclei, the history of only one of which we are interested in following. This sperm nucleus unites with the egg nucleus within the ovule. When this union has been accomplished the egg is said to be fertilized. Germination of the young plant so formed is then possible.

Giving the Young a Start in the World

After fertilization has taken place, the petals of the flower wither and drop away; the ovary is left to complete its work of developing the plantlet or embryo. The tough walls of the ovary, now called the seed-pod, make a safe shelter for the young. Each plantlet has its own coat within which is wrapped a goodly supply of food upon which it may live until it is ready to take care of itself.

When the plantlet is fully matured and ready to start in the world, the dry lily-pod bursts with such a sudden snap that the seeds are flung out like tiny cannon balls. If a seed is fortunate and falls upon good ground, it later absorbs moisture and the embryo or plantlet begins to grow. The brown, protecting coat bursts and the green head is pushed up into the sunlight, while the rootlets search far and wide for food. Time passes, but by and by the young plant reaches maturity, produces its blossoms and finally its seeds.

Since it may take several years for the lily to produce its blossom, advantage is taken of the plant's habit of reproducing itself by means of bulbs to hasten the blooming. Cultivated members of the lily family are grown so readily from bulbs that little attention is given to their seeds. We do, however, frequently find among our many garden forms opportunity to trace the seed history.

The formation of flowers with their reproductive organs, the fertilization of the egg by the sperm cell, and the ripening of the seed, are all steps in the sexual reproduction of plants. It is well to remember, however, that the higher plants are usually capable of reproducing themselves by means of bulbs, buds, slips, and runners as well as by the sexual method described for the lily. All of these means of perpetuating their kind keep plants from destruction and from being eliminated from the world in which they live.

THE GIANT SILKWORM OR CECROPIA MOTH

Few children, with opportunity to ramble in the woods, fail, sooner or later, to discover the cocoons of the splendid Cecropia moth, or giant silkworm. On account of its beauty, great size, and the wide range of its distribution, this moth has been chosen to illustrate the interesting life-story of all moths.

Every spring brings its caterpillars, and every autumn the leafless trees reveal the silken cocoons, the cradles of the next generation. Nor is the emerging moth one whit less marvelous to-day than in the ages gone by, when men saw in this transformation of the crawling caterpillar into the brilliant winged adult a symbol of the spiritual birth of the human soul.

Gather, on some of your winter walks, the great gray or brown cocoons you are sure to discover among the naked branches of the willow, maple, cherry, or other trees and shrubs, and keep them in your home.

When the Moth Emerges from the Cocoon

Watch the cocoon carefully when the warm days of May or June come, or you will miss the moment when the moth makes its way out of its winter chamber. Often you will hear the movements of the chrysalis before the broad head and shoulders are pushed through the funnel-like opening at the end of the cocoon. Gradually the stout legs reach forward and cling fast to any near-by object. By this means the short thick body with its crumpled wings is drawn out. The wings now hang limp and damp as the moth clings to a twig near its cocoon, but after a time they expand rapidly until they reach the full size of 6 or 6½ inches across. As they dry, the moth slowly fans them forward and back, exercising the muscles, thus gaining strength for flight. (See Plate II.)

The beautiful plumed antennæ on the head, as well as the size of the body, will indicate whether the moth is male or female, the male having the fuller, finer plumes. He has also

the smaller body, and is a better flier than the female. In his plumed antennæ are the scent pits upon which he depends to find his mate, often following, for great distances, the odor she exhales.

The Mating of the Moths

The mating takes place almost immediately after the female emerges from the cocoon. The sperm cells of the male are discharged directly into the body of the female, and often the mating moths are found with their bodies united. Seeing two of these great creatures with their bodies joined together is a sight to hold the wondering attention of any child, and offers an excellent opportunity to explain the meaning of egg fertilization through the union of the father and mother.

Hatching and Growth of the Caterpillar

The eggs are deposited in irregular clusters and fastened firmly to a leaf of the food-plant upon which the young caterpillar is to feed. Instinctively the winged mothers seek out the proper food-plants for their babies, though they themselves never take any food during their adult life. The eggs hatch in about ten days. If you are watching, you will see the sharp jaws of the baby caterpillar nipping away parts of the shell until the head is free, and the rest of the caterpillar's body is drawn out through the tiny hole. It is always a surprise to see the little black caterpillar looking so unlike the beautiful parents. At first it is quite black and covered over with queer bumps and bristles. All day and all night it does little but eat and grow. At last the skin is too tight and it crawls away to await the time when the outer skin splits down the back. The caterpillar then makes its way out of the tight skin, looking bright and fresh. The full-grown, brilliantly colored, caterpillar is not at all like the bristly, black fellow that came from the egg. It is frequently four inches long and as big around as a man's thumb. The body is now green with a bright blue stripe along the back, while along each side rise a double row of blue tubercles with two rows of yellow ones

PLATE II

The eggs of the Cecropia moth are attached in clusters to the food plant. From the eggs emerge the caterpillars which are at first black and later become large and brilliantly colored. When full grown the caterpillars spin silken cocoons and change into heavy-bodied chrysalides. In the spring the moths creep out of the cocoons, their wings being short and damp. After the wings have expanded and dried the adults are ready for flight. Five stages are shown in the illustration.

down the back. Near the head are four larger, orange-red, tubercles decorated with black spines. The caterpillars are well worth looking for, yet, as you can imagine, they are not easily found. Their color helps them to hide in the green foliage upon which they feed.

Spinning the Winter Home

When the time comes for the caterpillar to change to the chrysalis, it loses its bright color. A twig is sought and preparations are made to spin the cocoon. The caterpillar holds fast with its strong back feet and reaches forward as far as the long, strong body will permit. From a tiny silk tube in the lower lip are spun the first supporting lines. These silk threads are very strong, and give the caterpillar his familiar name of 'American Silk Worm'. The first lines form a frame-work upon which is fastened other threads, until the outer wall of the cocoon is completed. This usually takes on much the shape of a hammock. The threads are woven at first into a cream-colored fabric, but this darkens on exposure. Within the hammock the spinning continues, until the caterpillar has woven an inner chamber of much finer mesh, separated from the outer, protecting layer by a space filled with loosely woven threads. The air chamber between the outer and inner layers makes the inner cell less liable to sudden changes of temperature. The weaving of this inner cell is hidden from view by the outside coat. Within the inner chamber the caterpillar rests after its spinning work is done. Finally, the caterpillar wriggles out of its skin for the last time. An examination now of the inside of the finished cocoon will reveal the transformation which the caterpillar has undergone in becoming a heavy, dark brown chrysalis.

Examining the Chrysalis

If you desire to make this examination of the chrysalis, cut carefully through the two silken covers. This will be no easy task, for they are surprisingly tough. They were made to shed the snows and rains of winter, and are tight enough to keep out the cold winds, and tough enough to

discourage an enemy eager to tear the cocoon open for the tender bit of food within. The chrysalis itself rests with the head directly beneath the long funnel-like airshaft through which it will emerge when the time arrives. The outlines of the head, antennæ, legs, and wings (Plate III) may be seen beneath the thick, brown, chrysalis coat. In this state the chrysalis remains, until the warm days of spring. The coming forth of the winged adult completes the story of the moth.

The Great Family of Insects

The insects form the largest group of animals in the world. All of the butterflies, ants, bees, wasps, beetles, etc., go through a transformation from egg to adult resembling in some measure that of the moth. In most of these forms the mature insect mother deposits her fertile eggs which hatch in time into caterpillars, or larvæ. This first or egg stage varies from a few days in some insects, to several weeks or months in others. In the second stage, the larvæ may be legless grubs as in the case of flies, bees, wasps, ants; or they may have but six legs like many young beetles. In all the insects named, however, the immature creatures bear not the slightest resemblance to their parents, nor will they until they have passed through a third stage, the chrysalis or pupa. This third phase may be longer or shorter in duration, according to the nature of the insect. It may be passed within the protecting silken cocoon, like most of the moths, merely hung from a twig as a naked chrysalis, like the butterfly, or lie buried in decayed wood or under the ground. Following this quiet pupa period, the mature form emerges and thus all four of the links in the insect's life are completed.

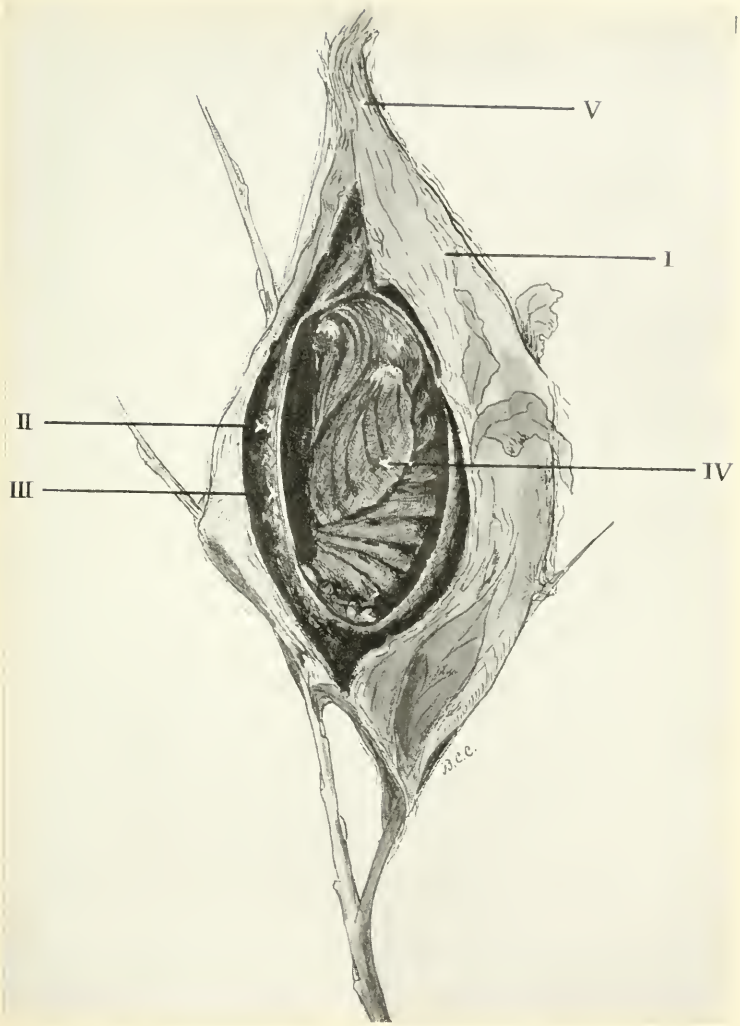
In these forms four stages are always in some measure present. First the eggs; second, the larva commonly called the caterpillar, grub, or maggot; third, the pupa or chrysalis (often in a cocoon); and fourth, the adult.

Keeping Caterpillars for Study and Observation

Almost any of the more common forms of caterpillars may be kept in a simple cage, made of a box with a net covering.

PLATE III

When the Cecropia moth cocoon is cut open the following parts may be seen: The outer fine weatherproof network I; the coarse intermediate mesh II; and the firm inner cocoon III, smoothly varnished inside to form the cell for the chrysalis IV. The chrysalis rests upon the fragments of the cast caterpillar skin with head at the top beneath the air funnel V. Various parts of the moth—the head, antennæ, folded legs and wings, and the segments—may be made out.


V
I
II
IV
III

Care should always be taken to provide the caterpillars with the same food upon which they are found. Many caterpillars are extremely particular about their food and will starve to death rather than eat another kind of plant. The brilliantly banded caterpillars of the monarch butterfly are an instance of this peculiarity, as they will feed only upon the milkweed. The dainty white cabbage butterfly, on the other hand, lays its yellow eggs upon a great variety of food plants, such as turnip, cabbage, or the garden nasturtium, all of which with many other food plants are readily eaten by the green caterpillars of this butterfly.

Provided with plenty of the right food, with ample room to crawl about, and pure air to breathe, with provision made for the proper shelter of the chrysalis, it is an easy matter to rear any of the more familiar caterpillars.

THE FISH

Fishes move through the water much as birds do through the air, easily, buoyantly, and gracefully. They swim with their tails, balancing and directing themselves with their fins. The swim-bladder reduces the exertion of keeping afloat; the resistance of the water is reduced by their slippery scales; and the fish is helped forward by the closing in of the water behind the wedge-shaped body. Fishes were the first animals with jaws and a back-bone. It is no wonder, then, that they have grown, through these long ages, to fit their environment as perfectly as any living form.

Small fish may be kept in aquaria, especially if they be supplied with water plants and pond scum, which by giving off oxygen, and taking in of carbon dioxide, keep the 'balance' between the oxygen used by the fish and the carbon dioxide given off by them. Fish should be fed very little, and protected from the hot sun. Very rarely, however, can fish be made to breed in an aquarium. The conditions are so unnatural that the sensitive reproductive organs remain dormant.

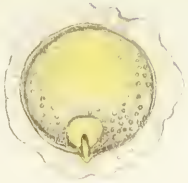
Lessons from Fish Roe

The scientist, however, with his microscope, may observe something of what takes place in the preparation of the male and female germ cells of either plants or animals, their union, and the formation of the new individual. The ripe eggs and sperm cells of plants, and the ova and sperm masses of the lower animals, especially of fish and poultry, are readily seen. From these and from the records of science, we may piece out the story of reproduction.

Since fish cannot be bred in aquaria, the roe, or egg masses, of female fish, together with the greatly distended sperm sacs of the male, obtained at the market in season, will help to focus attention while the story is told of the way fish live, lay their eggs, fertilize them, and of the way the young grow.

PLATE IV

The embryo fish forms upon the surface of the yolk of the egg, Figures I to V. (After Keibel.) A protective membrane surrounds yolk and embryo which is shown partially removed. Figures VI and VII represent two stages of newly hatched fish in which the yolk is being gradually absorbed. The adult, VIII, is drawn on a much smaller scale in comparison with the other figures.



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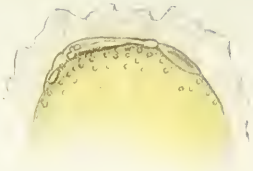
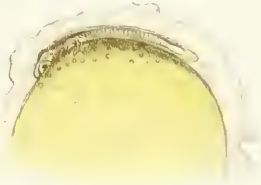
II



III

IV



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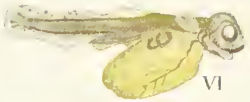

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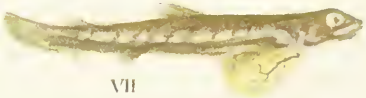


VII

VIII

The Father and Mother Reproductive Elements in Plants and Animals are very Similar

The ova or eggs of fish are produced by paired organs called ovaries, attached to the back body-wall. In the breeding season the eggs, which have heretofore been very small, increase rapidly in size so that great numbers of them, many thousands, indeed, fill the egg sacs of the female. Here they are held until needed. The eggs in the ovules of plants, the seed to be, are very similar, except that in the case of the plant the organ that produces the eggs, the ovary, dies and falls away when its work is done. In the fish it shrinks to small size until the next breeding season.

The sperm cells of the male fish, and the sperm cells found in the pollen of flowers perform a similar service in reproduction. The two spermaries in the male fish are in the same position as the ovaries of the female. The product of the spermaries is a heavy, whitish, glistening fluid, called the 'milt'. Under the highest powers of the microscope this 'milt' is shown to be a mass of millions of moving cells. Each cell is provided with a swimming tail or lash. These sperm cells are so small that it would take six thousand or more of them, placed side by side, to measure an inch. The 'milt' is deposited in the water by the male fish in the immediate vicinity of the eggs, which but a moment before, have passed from the body of the female. By means of their swimming tails, the sperms find their way to the egg, and one sperm cell enters and merges with the nucleus of each egg. The sperm cells in the pollen of plants accomplishes the same end, except that the plant sperm cells have no swimming tails and must depend upon the wind or insects to carry the pollen to the pistil.

The Interesting Story of the Salmon

Fishes lay their eggs in many different places. Some are scattered freely over the bottom of the stream, pond, or sea; some are buried in the sand; some, like the cod, float upon the surface of the ocean. A few fish, like the little stickleback, make special provision for their eggs and young by

building a nest. Most eggs, when left unguarded, are destroyed or eaten by other fish.

Some kinds of sea fish make long journeys up streams or rivers, even going as far as the head waters, to find suitable places to spawn or lay their eggs. The salmon affords one of the most remarkable examples of this habit. There are two kinds of salmon about the American shores; one known as the Atlantic salmon, and the other the Pacific salmon with its several recognized varieties.[1]

The Atlantic salmon (see Plate IV) spends most of its life in the sea, but in the early spring, when the female is literally filled with eggs, and the male with sperm, they make their way up the rivers of the North Atlantic coast, leaping cascades and barriers and forcing their way up rapid and shallow stream beds, until the appropriate spawning ground has been found. During this time the males indulge in many fierce combats. Arriving at the spawning ground, the mother salmon scoops away the sand and gravel of the bottom with her tail, and in this nest she lays a few of her six or ten thousand eggs. Then she moves aside, and the male takes her place over the 'nest', and casts his milt quickly upon the eggs, as there is barely time for the sperm to reach them before the envelop surrounding them has become turgid with water and therefore impenetrable to the sperm cells. Sand is then scraped over the eggs, and the pair repeat this process over and over again until all the eggs have been extruded. It may take several weeks to complete the egg laying.

While the salmon are in fresh water they take little or no food. The Atlantic salmon grow lean and unwholesome in appearance as they make their way back to the sea. The Pacific salmon seldom reach the sea alive.

How Young Salmon Hatch from the Egg

The eggs of salmon are about one-quarter of an inch in diameter, and are large for fish eggs. This means that they are well provided with food enough to form the embryo and

[1] Read the story of the Pacific salmon in *Science Sketches* by David Starr Jordan.

to feed it for several weeks after it hatches. Figures 1–5 (Plate IV) show the salmon egg with the outer envelop or membrane laid back in order that the embryo may be more readily seen at various stages of development. When hatched, the young wriggle up through the sand of the stream bed. They present a curious appearance (Figures 6 and 7, Plate IV) with their thin, transparent bodies, and big sacs of yolk, which nourish them during the first weeks of growth. This early stage is spent quietly resting on the bottom of the stream, or hiding beneath stones and crevices, out of the way of their many enemies. By the time they are large enough for real activity, the water is warm and their food plentiful.

It may be the third spring before these fish pass out of the river into the sea. Even then it may take another year before they are grown into full-fledged salmon.

The Trunk Lines of Life

The fish stand at the foot of the ladder of back-boned animals. All of these animals, from fish to man, take much the same steps in producing their young. With few exceptions, fish, frogs, and birds supply their eggs with yolk enough to build the embryo; and sometimes, as with fish and less so with frogs, enough food is also stored to nourish the young for some time after birth. The great majority of the higher forms, the mammals, including man, cannot store enough yolk for such large bodies, and for such long periods. Hence the young, after exhausting the yolk of the egg, and while still in the egg-tube (now called the uterus) of the mother, attach themselves by means of suitable organs and take their building materials from her.

From fish to man, the back-boned animals resemble each other very closely in their development. These resemblances are seen not only in the growth from egg to adult, but in the parallel way in which the growth changes take place. There are many differences as well as resemblances in their development, and these make themselves most manifest when the embryo of each animal approaches birth. Indeed the history

of the vertebrate animals on the earth might be compared to a long road in which the fish branch off very early, the frogs a little later, and then the birds take their separate way. Mammals, like the rabbit, keep on the main road until their time comes to turn aside. Finally the parting of the ways comes for the higher apes and man.

Biological science confirms in a thousand ways this conception of a long road with its many branchings, or a great tree with its forking limbs at higher and higher levels. The higher mammals are the terminal points on a great trunk line of life.

If one keeps in mind an image of this nature, the similarity in the methods of animal reproduction will be understood. It is to be expected that, on the whole, animals resembling one another will have the same modes of development from the egg to adult, and that there will be a marked tendency for the higher forms to repeat, in the growth of the embryo, the steps that are taken in forming the embryos of the animals below them. The process in general is one of adding something new to an old pattern, rather than that of getting up a new pattern for each level of advancement in organic life.

THE FROG

It is a mistake to think that only human beings have family trees. Frogs—all animals—have them too, only we think of their tree not as made up of generations, but of a series of species or forms that have gone before in very ancient times. The most interesting thing about the frog is that his ancestors, way down at the root of his family tree, helped to bridge the gap between the water and the land animals. This was really a wonderful achievement, and, to this day, the frog in his development keeps repeating the feat, which is no less wonderful than in the first frogs. These ancient frogs were also the first back-boned animals to acquire hands and feet with fingers and toes. They were the first to crawl out of the water upon the land, and to breathe with lungs instead of gills. Every frog which reaches maturity repeats again the story of his race in his earlier stages, harking back as a tadpole to the simpler life in the water, and as adult living the life of the higher land animals.

The Race for the Land

Nature is in great haste to turn the tadpole into the frog. Why? The rapid drying of the shallow ponds and pools in which frogs and toads lay their eggs would result in the death of the tadpoles if they had not already changed to frogs and were ready to breathe air and climb out upon the land.

Toads usually lay their eggs in shallow ditches and pools of the open fields. Their life from egg to diminutive toad is only a matter of six or eight weeks. It, therefore, matters little to them that the pools dry up quickly, since, as adults, they are practically land animals anyway. The common frog, however, requires three months or more to mature, and the bullfrog, whose eggs are laid in the deeper water of the marshland, does not make the change until the second, or even the third, year.

In a Cradle of Jelly

Frog's eggs are laid in a mass of transparent jelly, looking much like the white of an egg. (Plate V.) Each of the thousand or more black eggs is surrounded by three layers of the jelly, Figure 2, and together they float near the surface of the water, a clear, buoyant mass among the water weeds. This jelly envelop is also a great protection from possible enemies, as it is so slippery that the eggs cannot readily be picked up or eaten by water-fowl or fish. The globule of jelly aids in the development of the egg by focusing the heat rays of the sun upon it. Frog eggs are black on top and light yellow below. The embryo, the 'forming animal', takes shape in the black portion while the light material below is the food or yolk. In three days after being laid, the head and tail become somewhat distinct, while the middle part remains attached to the yolk. By the end of a week the tadpole embryo begins to wriggle and looks like 'an animated comma'. On the ninth day they twist and squirm their way out of their jelly cradles. They remain quiet for at least a few days, attaching themselves to stones and water weeds by a sucker-like organ beneath the head. Frog tadpoles have no mouths for sixteen or seventeen days; they come out of their jelly nests blind.

Toad eggs are laid, not in masses of jelly, but in double strings, usually draped and hung about the pond weeds. They are smaller than frog eggs and are black all over. Since their development is more rapid than the frog's eggs, they are more interesting to the observer.

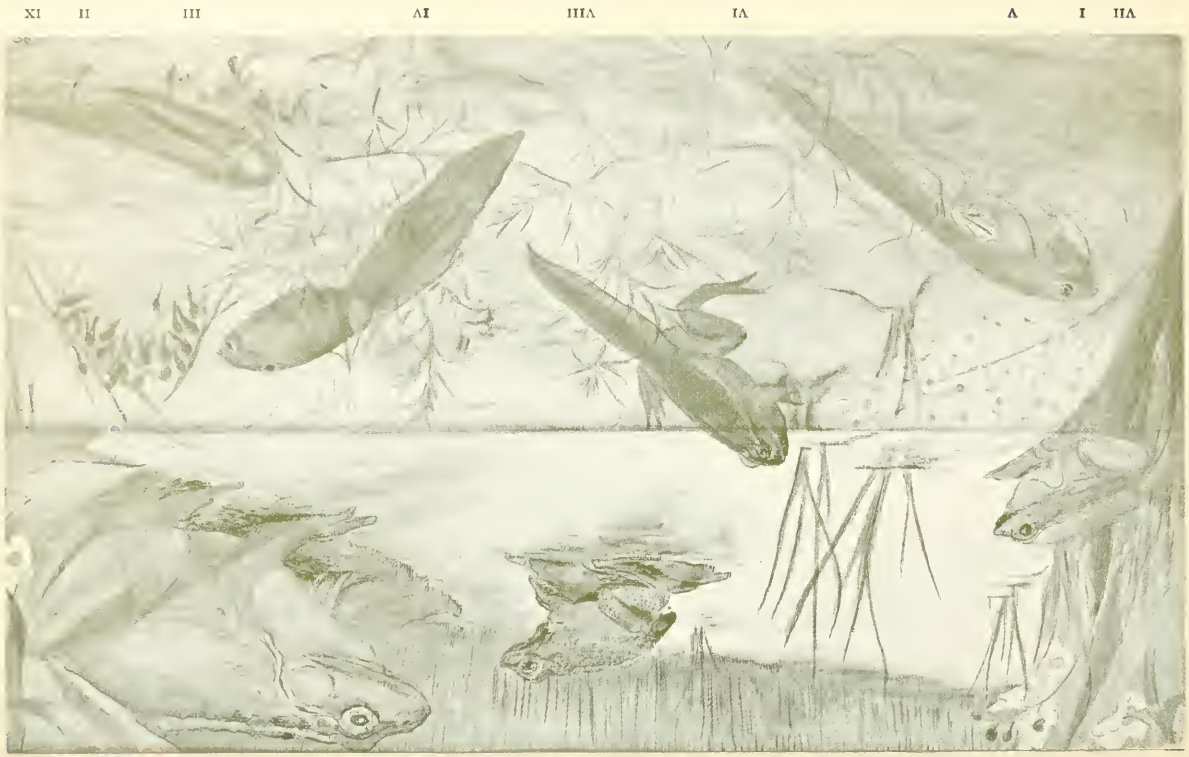
Tadpole Days

The next three or four months are stirring times in the life of the tadpole. With no parents to care for him, he is surrounded at every turn by enemies that seek his life. Within, his body is a theatre of opposing forces. One set of growth forces are striving to make of him a larger and stronger fish-like animal, breathing through gills, and swimming with a powerful tail. Other forces set in very soon to reduce his size, to utilize the substance in his tail, to produce limbs and

PLATE V

For convenience of study the development of the frog from egg to adult may be divided into nine stages.

The eggs float in a mass of jelly I. Newly hatched tadpoles usually cling to water plants by sucker under the chin II. Very young tadpoles have a gill fringe and breathe like fish III. Then the hind legs grow out; the tail is still long IV. Another stage is marked by the appearance of the left foreleg—pushed out from beneath the fold of skin that now covers the gill V. All four legs are used for swimming; the tail begins to decrease in size; tadpole breathes air out of the water VI. Most of the time is spent out of water. Tail is much shorter VII. The tadpole changes into a small, but real frog. Tail reduced to a stub VIII. At last comes the fully matured frog IX.


XI II III AI IIIA IA A I IIA

lungs, and to endow him with the instincts of a land animal. It is no wonder, then, that amid these great changes many of the tadpoles which escape their enemies, die.

Metamorphosis

We have no common English term to give just the meaning of the far-reaching change that this word, metamorphosis, implies. There is the change of form (morphosis), but there

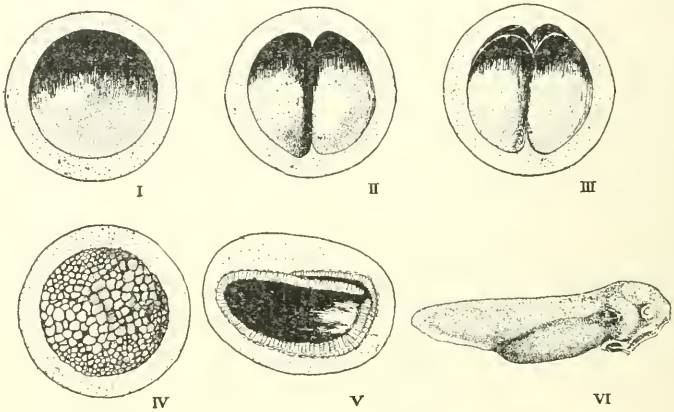


FIGURE 2

Six steps in the early growth of the frog embryo are shown here. Each stage is surrounded by its jelly envelop.
The fertilized egg I, divides into two cells II; a second division at right angles to the first, results in four cells III. Cell division continues until a hollow ball is formed IV. The embryo lengthens V (a section through the long axis of the embryo) and takes on the shape of the tadpole VI.

is also a play of higher (meta) forces drawing the tadpole out of his tadpoleness into a larger life.

Tadpole and frog overlap. Before the poliwog days are ended, he ceases to eat and apparently lives on the substance stored up in his tail, and the fat he has accumulated. By and by the tail is reduced to a stump, the hind legs lengthen, the mouth broadens, the eye becomes large and prominent, the body shortens, and many other changes take place, until,

one day, there is a perfectly formed frog on a small scale. He sits, through the long hours, on stick or stone or lily-pad

With Arms Akimbo.

The little forearms are used to hold up the body while the long muscular hind legs are ready for the leap to safety. He feeds on insects and worms now, and though he looks and acts sluggish he is capable of very rapid motion. Let an insect approach and the sticky tongue, fastened at the front of the mouth, just the reverse of ours, flashes outward and folds around the prey. Frogs never drink, but take most of their water through the moist skin which is shed three or four times a year as the frog grows.

Frogs and their cousins, the toads, escape the rigors of winter by retreating, hind end first, into the moist earth and pond bottoms below the frost line. They are neither dead nor asleep, but are in a condition of reduced or lowered vitality, called hibernation. This is a very economical way to spend the long months of cold. A little warmth in the early spring serves to call them forth. Having saved so much strength and energy by the long rest, they are ready almost at once, to take up the serious business of the moment, early announced in

The Courtship Chorus.

Who has not heard the insistent, rhythmic beat of many frog voices? Sometimes they sound like bagpipes, and again, when near at hand, like jewsharps, vibrated under water. Through the season many different notes will be detected corresponding to the different species of frogs and toads.

What is the Clamor all About?

It is the call of the males to the females, and, in the psychology of frogdom, is probably intended to rouse the females to a sense of their duties.

As the time for laying the eggs approaches, the male mounts upon the back of the female that he may be at hand the moment the eggs with their closely wrapped, gelatinous en-

velops are discharged from her body. The milt from the male passes down the sides of the female and thus reaches the eggs as they emerge.

In a very short time after reaching the water, the egg envelop swells and in a few hours the cycle of life begins anew. Egg to tadpole, tadpole to frog, frog to egg again—a never-ending series.

THE CHICK

Fish, frog, bird, mammal, and man are, for us, so many landing places in the stairway of organic life. They are, in other words, members of one series since they are alike in many particulars. They differ, however, in the manner of producing their young as well as in other ways. Either the young come from eggs which have been supplied with a large amount of food material and are detached from the mother's body, or they feed for a brief time upon the egg yolk and then attach themselves to the parent's body, drawing their nourishment from her through a cord-like tube. Most fishes, frogs, reptiles and birds belong to the first class, and with perhaps two exceptions, all mammals, including man, belong to the second class. In each case the required nourishment is supplied to the growing young. Naturally, more protection is afforded the offspring when it is carried within the mother's body, but this is offset by the smaller number of young for which provision can be made.

In the series which we have chosen to illustrate ascending life, we come now to the bird. Among birds the best form to study is the chick, the little self-sufficient offspring of the humble barnyard fowl.

The Miracle of Twenty-One Days

The hen's eggs, even those in process of incubation, are so familiar that we rarely stop to think of what is going on inside the egg in the three short weeks. If one were to take from Biddy, or from an incubator, one egg a day for the first five days and carefully remove the top of the egg, a rapidly changing scene would present itself.[1] One is amazed at the extraordinary rate of growth of the chick which is many times

[1] It has been suggested that young children should not be shown the development of the chick, since the opening of the shell involves the death of the embryo, and hence gives the child a shock. The writer has never seen children react in this way, but since the purpose of the demonstration is to show that life exists immediately after fertilization takes place, it should not be continued in later stages if the child is distressed or if it is not convinced that the sacrifice is justified by what it teaches. Older children will not offer a problem of this nature.

PLATE VI

After twenty-one days of incubation the apparently lifeless hen's egg is transformed into a living chick. The germ found on the surface of the yolk of a fertilized egg contains the living, hereditary material, which, with the coöperation of heat, air, and moisture, builds the body of the chick, particle by particle, out of the yolk and albumin (white) of the egg.

First day of incubation I; third day II; fifth day III; twelfth day IV; eighteenth or nineteenth day V; hatching of chick VI, VII; beginning life VIII. See the text for fuller explanation of the illustrations.

A system of blood vessels spreads over the yolk and forms the germ disk as represented in IX. (After Lillie.) The disk without the underlying yolk is shown here. The liquified yolk is absorbed by the tiny blood vessels and is then pumped by the chick's heart into its body for building material.

faster than at any later period of its life. Nor is our astonishment lessened when we see the rapidity with which the damp, newly-hatched chick adjusts himself to the world. All he has to do after birth is to grow into chickenhood which he rapidly proceeds to do within a year.

Six Chapters in the Life Story of the Chick

There are several important things to observe in the life of the chick. We should note the parts or structure of the egg itself; where the yolk, the essential part of the egg, comes from; how the egg acquires its coating of albumin and shell; how the egg is fertilized and made ready to build the chick; the way the body of the chick takes form upon the yolk; and when the chick finishes its growth, and how it breaks the shell.

The Four Parts of the Hen's Egg

These are 1st, the shell; 2nd, the albumen (or white); 3rd, the yolk; and 4th, the germ. The first three parts of the egg are familiar to everyone, and the germ, which lies upon the upper surface of the yolk, moving to this position whenever the egg is turned, may be seen if the egg is carefully broken in a dish.

The Source of the Real Egg

The germ and the surrounding yolk, the real egg, which together form one big cell, one of the largest in the plant and animal kingdoms, comes from the ovary. The ovary is attached to the back body wall of the bird above the kidneys. It contains thousands of immature ova or eggs in various stages of growth, most of which are never used. For a definite period in the year, groups of the ova acquire much food material, or yolk, and, when they are fully matured, break through the membrane of the ovary, one at a time, and are drawn into the expanded, cup-like end of the oviduct or tube leading from the ovary to the outside.

The Egg Shell a Discovery in Protective Envelops

The ova move slowly down the oviduct, perhaps several of them at a time, but each keeping in a different place in

the duct. They are said to gain more yolk as they pass along. Turning about on their long axes, they gather albumin or 'white' of the egg from the glands lining the oviduct. Near the lower end of the duct the egg receives its final covering, the lime shell, which on passing out of the tube, is soft and pliable until hardened in the air. For a land animal whose young are formed outside the body of the mother the shell with its rigid yet porous wall is a genuine discovery. How great an improvement it is, too, over the gelatinous covering of the fish or the frog!

The Egg is Started on Its Course of Development by a Free Swimming Cell from the Male

From time to time the male bird deposits at the entrance of the oviduct hundreds of thousands of male sperm cells. These are very much smaller than the ova—so small, indeed, that it is necessary to use the highest powers of the microscope before they are clearly visible. Each sperm cell is equipped with a long swimming tail, with which to make its way up the oviduct. In the upper part of this duct, above the region of the albumin and shell glands, they await the coming of the ova. Although so many thousand sperms are ready to fertilize the ovum, but one really does so. A few may enter the great yolk sac and move by some subtle attraction toward the mother-germ; all but one, however, are halted before reaching the nucleus of the egg. The fortunate sperm that passes within the prohibited zone unites with the egg nucleus, leaving its tail in the yolk.

The sperm cell undoubtedly starts the egg on its course of development, but it also does something more. It contributes its share of inheritance from the father, and, through him, from all his ancestors.

Modeling the Chick Out of the Yolk

As soon as the two germ cells have united, the work of building the new body begins. The united cells divide and subdivide. At first there are two, then four, then eight, and so on, the divided cells remaining in contact to form layers,

folds, and walls. The speed with which the new body is built is due to the rapidity of cell division. Soon there are hundreds of thousands of these rapidly dividing cells. Development begins in the egg on its way down the oviduct, but does not proceed far until incubation begins.

The First Day. We are ready now, to look at a series of incubating eggs. Open the upper side of the egg. This is best done by inserting the blade of a pair of small, sharp-pointed scissors and cutting around the upper portion of the egg shell.[1] Toward the end of the first day a small germ-disc will be seen lying upon the top of the yolk. The disc is a network of blood vessels, the first steps in the formation of a circulatory system between the yolk and the growing embryo which now appears as an elongated depression in the center of the disc. Figure I, Plate VI.

The Second Day. The beating of the heart will be seen on the second day. The outline of the head appears and the germ-disc has increased its diameter.

The Third Day. Figure II shows the state of growth on the third day. The yolk has expanded by absorbing moisture from the outside. The curve of the body is plainly indicated, the head is greatly enlarged, and the eyes well marked.

The Fourth Day. By this time the wings and legs are budding out from the body, the eyes assume enormous proportion, occupying almost the entire forepart of the head.

The Fifth Day. The chick seems all head, and the head, all eyes. This is nature's way of looking to the most important organs first. Wings and legs and tail have grown longer. This is about the stage represented by Figure III.

The Tenth Day and After. If we omit the stages of the four following days, and open an egg on the tenth day—eleven days before hatching—we shall find a whole chick. The yolk and 'white' have been enclosed within the body. By the twelfth day (Figure IV) the chick occupies almost the entire egg, and by the fifteenth day some of the feathers,

[1] The embryo may be best observed if the opened egg is immersed in warm (normal) salt solution. Use one level teaspoonful of salt to one pint of water. The heart will continue to beat for some time when the opened egg is placed in this warm solution.

beak, claws, etc., are fairly well formed, and the chick is ready to enter the last stage of its egg life, that of breaking through the shell. (Figure VII.)

How the Chick Breaks Through the Shell

The chick has now exhausted its food supply and the time has come to break through the shell. Toward the end of the nineteenth day peeps may be heard as the young bird begins the work of releasing itself. On the tip of the upper beak is a horny knob called the 'egg-tooth' which may be seen on the beaks of newly-hatched chicks. When lying within the shell the chick's head is near the equator of the egg, and by rubbing against the shell with its toothed beak, at the same time turning about in the egg, it wears a groove through the whole circumference of the shell. The struggles of the chick finally break the thin groove, and there emerges a completely formed, well-equipped young fowl. (Figures VI, VII, VIII.) Chicks must have had a normal development and much vitality in order to make their way out, for it is no easy task and the weaklings usually perish within the shell.

Chicks Compared with the Young of Other Birds

The domestic fowl belongs to the same order of birds as the quail, pheasant, grouse and turkey. They are called ground birds and their young are able to care for themselves almost at once after hatching. Notwithstanding this, naturalists speak of them as lower and more coarsely organized than the thrushes, doves, warbles, and other song-birds whose young are hatched in a wholly helpless condition and are, therefore, dependent upon their parents. This dependence makes necessary a longer or shorter mating of the parents, the establishment of the home or nest, and the continued care of one or both parents.

Although some birds are helpless at birth, and others quite precocious or matured, all go through the same course of development from the fertilized egg. The chick is chosen only because the transformation of yolk into chick has long been studied, and the incubating eggs are easily obtained.

THE RABBIT

No animal beside the dog and the cat is better known to childhood and more loved than 'bunny'. To the gardener and orchardist, however, he is ever a scourge; to the hunter, jacks and cottontail often remain the only game of the neighborhood. The rabbit is a fearsome little creature since his only means of defense are his fleetness of foot and his keen hearing. If neither fleet-foot nor keen ear save him, his wonderful rate of reproduction may keep him from destruction as a species if not as an individual. Whether as pet, enemy or game, the rabbit lives, whenever possible, close to the habitations of men, loving the briar thickets along the edge of the road, coming forth mainly in the dark of the night in search of food.

On Being Afraid of One's Shadow

The great problem in the life of the wild rabbit is to live long enough to reproduce its kind. Although this takes less than a year not many out of the great numbers born succeed in reaching this age. In spite of its fleetness of foot and its good hearing the rabbit often falls a prey to one or another of many enemies. Man destroys vast numbers; foxes, owls, and weasels beside a host of other enemies take their toll. The rabbit's habit of seeking shelter in holes and burrows results in capture more often than in escape. Not for a moment, asleep or awake, is the rabbit off his guard. The long ears are poised to catch the least sound, the nostrils are ever keen to detect the faintest scent of the enemy. Even in sleep the body rests upon the long hind limbs, ready for the sudden leap.

Wild rabbits are properly hares, only the domestic animal being a true rabbit. Rabbits and hares differ considerably in their habits, color, size, and the condition in which the young are born, those of the domestic rabbit being much more helpless. It is not likely, however, that common usage will make the necessary distinction between rabbits and hares.

Education through Pets

How blessed is the child who can have a pet! An animal that is all his own, over which he may exercise his affections and his will, and through which he is given the opportunity to establish right relations with the lower forms. To assume the care of animals, to meet and anticipate their needs, to watch the birth and growth of their young, to mate and improve the stock, are all, in themselves, a discipline and an education. Animals have civilized man quite as much as he has domesticated them.

Rabbits make splendid pets; they are hardy and have few needs. Next to the dog and the cat, they have endeared themselves to all children.

From Birds to Mammals

It is seldom possible, and indeed not often desirable, to give formal instruction to children about reproduction, by beginning with flowers, and passing on to insects, fish, frogs, birds, mammals, and man. The inquiry or the question of the moment, whether it concern human birth or the meaning of the flowers, will naturally deserve first attention. However, it is desirable, as soon as possible, to convey an idea of the ascending order of life and the main characteristics of each of the great types. Information obtained about any plant or animal may be turned to account either in comparing or contrasting other forms already known to the child.

Our first thought is that there are very great differences between birds and mammals, so great as to belong to unrelated divisions of the animal world. There are, however, connecting links between them on the one hand; and between birds and reptiles, on the other.

The most striking difference between birds and mammals, as we know them, is the growth of the young from an egg outside the mother's body in the case of the birds, and the growth of the young from an egg inside the mother's body of the mammal. Without thinking, we say that the young of birds grow within an egg, outside the mother. This is not

PLATE VII

Nest of newly-born cottontails under cabbage leaves (above)
Mother with her young (below)

true, as both bird and mammal come from the fertilized egg, the only difference being that layers of food are stored about the egg of birds instead of gaining its supply, as needed, from the blood system of the mother. This method of feeding is not unlike nourishing the seed embryo of plants with sap.

Then, again, the young of birds at birth are either able to pick up their food (poultry and their allies) or are given their food partially digested by their parents (pigeons) or are fed insects and worms (song-birds). Mammals, however, feed their young for a longer or shorter time, a highly concentrated food, milk, which is formed by especially prepared glands, and stored temporarily in sacs, the mammæ. So important is this power to feed a prepared food and therefore to lengthen the growing period of the young, that it has given the name 'mammals' to this great group. In this sense, then, man is but a higher mammal.

How Rabbits Rear their Young

Wild rabbits or hares quite generally make their nests or 'forms' on the ground beneath a cover of grass or shrubbery. The nest is nothing more than a slight hollow lined with fur and grasses. The mother makes a kind of rough coverlet under which she tucks her babies when leaving them. So well hidden is the nest with leaves and litter that it is not usually seen until the foot steps into it. (Plate VII.) Domestic rabbits live in hutches following the burrowing habits of their European ancestors.

The young are carried but thirty days within the body of the mother. (Plate VIII.) Cottontail young are born quite hairless and blind (Plate VII), dependent upon the mother for nourishment and such protection as the nest may offer. So rapid is their growth, however, that they are turned out to shift for themselves in three weeks.

Although the mother rabbit faithfully discharges her maternal duties, the father rabbit shows no recognition of his own family and is sometimes said to kill his own offspring.

The Reproductive Organs of the Rabbit

Just as with the fish and the frog the reproductive organs of the rabbit consist, in reality, of but two structures, the

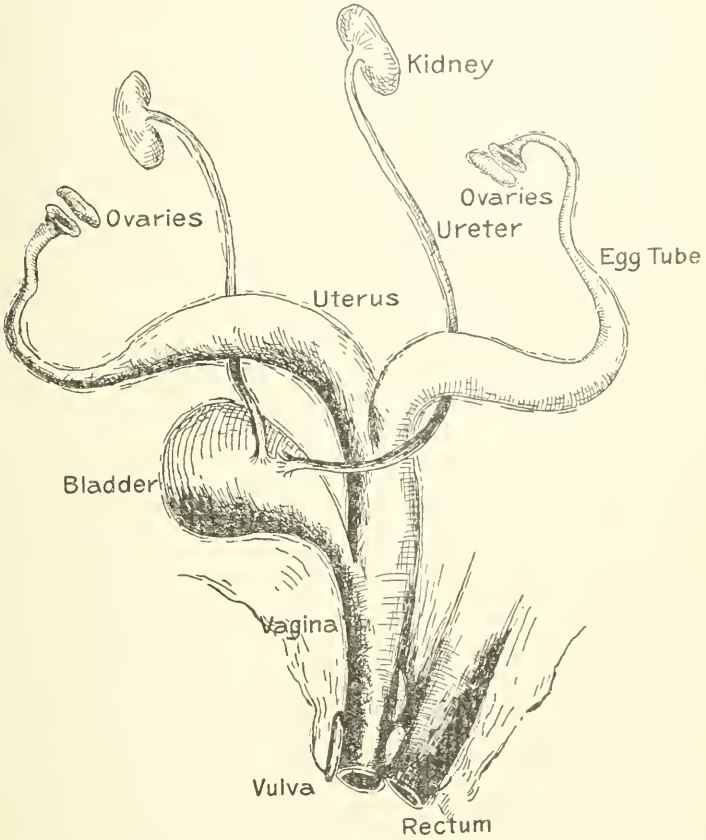


FIGURE 3

The reproductive organs of the female rabbit consist of the ovaries, the egg-tubes and the branched uterus. The urinary organs which are closely related to the reproductive, include the kidneys, the ureters and the bladder. Note that these two sets of organs utilize the same outlet, the vagina.

With here and there minor modifications the organs, as illustrated, are typical of most mammals. In the human female the uterus (womb) is not double or paired (see Fig. 7—page 64).

paired ovaries and the ducts which lead from the ovaries to the outside. The hen is no exception, except that one ovary and one duct have disappeared. The first structures, the

PLATE VIII

The mother rabbit carries her young in two long tubes, which together are called the uterus. (See Figure 3 for a sketch of the reproductive system showing the branches of the uterus.) When the uterus with the young is examined closely, as in the enlarged figure (below), it will be seen that each embryo is enclosed in a separate sac and draws its nourishment independently from the mother.

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ovaries of the rabbit, are but three-fourths of an inch in length and are attached to the body wall, behind and lower down than the kidneys. (See Figure 3.) The ovaries contain many eggs, only a few of which are used in the lifetime of the animal.

The second structures are the oviducts, leading, as in all other forms studied, from the ovaries to the vent. Instead, however, of being merely a straight tube through which the egg passes, as in the fish or frog, the oviduct now has three well-marked portions or divisions, the fallopian tube, the uterus and the vagina. (Figure 3.) In the rabbit, the paired tubes enlarge and join in their lower course to form the uterus or the place where the young are carried. The uterus, in turn, leads into the vagina or vestibule and then to the outside. In all of the lower forms that have been studied, the oviduct and rectum or alimentary canal join and have but one opening to the outside. The oviduct of the higher animals, however, has its own outlet. It is into this duct that the male introduces the sperm by means of a special organ, the penis.

The reproductive organs of the male mammal, while they seem to be unlike the female, correspond part for part. Here, too, there are but two paired structures, the testes, or sperm-producing glands, and the long tubes or spermatic cords through which the sperm passes. The penis of mammals and of man is simply a prolongation of the tube protected by folds built up from the margins of the duct where it emerges from the body. This organ conveys the sperms with more certainty into the oviduct of the female. Male birds have developed these folds to a considerable extent, the duck and goose family having gone the farthest in this direction. The penis because it is the most conspicuous of the visible reproductive organs is apt to receive undue attention. From the biological point of view it is an interesting evolutionary structure, and one that has developed independently in other forms than the mammal and for the same purpose; but, on the whole, the organ is of relatively small importance as compared with other parts of the reproductive apparatus since fertilization does take place in some animals without it. It

is desirable, therefore, that a clear idea of the whole of the reproductive structures be obtained, and especially of the really important ones, the ovary and testis.

The testes of many mammals and of man are found suspended on the outside of the body near the outlet of the spermatic tube. (In the rabbit, the subject of our study, the testes are not on the outside of the body except at the breeding season.) The location of the testes in this region apparently disproves the assertion that the male and female structures correspond. But the testes of the male of mammals and of man are found in the embryo, long before birth, in the same position as that occupied by the ovaries of the female, namely, back of the kidneys. Before birth there is a 'descent' or migration of the testes from their original place to the scrotal sac outside. Evidence of the change of position of the testes is seen in the spermatic ducts, which very early in the life of the embryo connect the testes with the penis, but later lengthen their tubes and follow the testes to their new position. They therefore form loops in front of and on each side of the bladder in passing from the testes to the neighboring outlet (Figure 6, page 63).

The eggs and the sperm cells of the rabbit share the lower portion of the canal leading to the outside with another product of the body, that from the kidneys. The kidneys empty their secretions into the bladder and the latter empties into the vestibule, not far from the outer end of the tube.

The History of a Fertilized Egg

At intervals, six or more small, naked eggs are discharged by the ovaries into the expanded end of the oviduct. On the way down the oviduct they may be met and fertilized by sperm cells from the male. If so, they immediately begin to develop, and by the time they reach the uterus have already thrown out finger-like processes which enter the walls of the uterus. Through these, oxygen and nourishment are drawn from the mother. The five or six eggs have taken up positions in the uterus, and here, as they grow, become surrounded by two envelops, each forming a sac, the inner one of which

is filled with fluid. In this way, the embryo is protected from all jars and pressures. At the end of the gestation period the young pass out through the vagina and, as we say, are born.

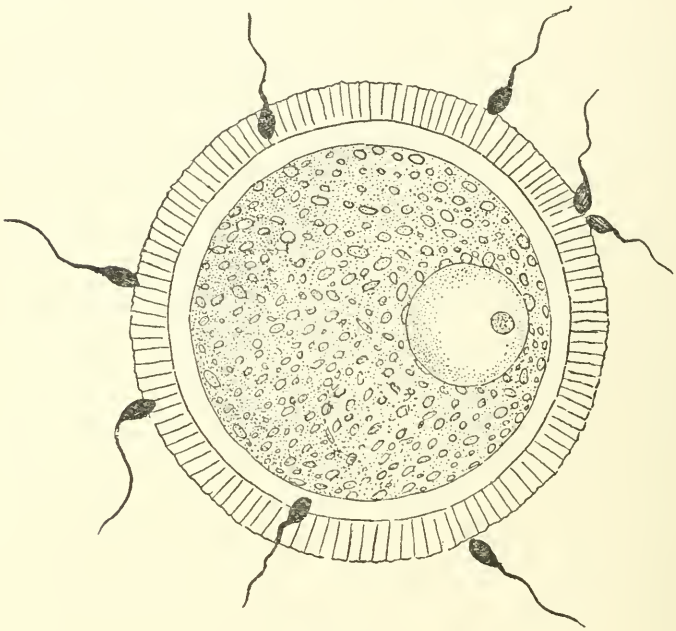


FIGURE 4

All mammal and human egg cells are essentially alike. The egg is surrounded by a transparent membrane; a small amount of food material is stored within the cell for use during the early stages of the growth of the embryo. A small round body, the nucleus, carries the hereditary material. Inside the nucleus is seen another body, the nucleolus. Sperm cells surround the egg and endeavor to pass through the membrane and outer wall of the egg. Highly magnified.

Should the eggs not be fertilized at once, they remain for a time in the tube and uterus; but eventually find their way to the outside, or are absorbed.

Lessons from the Rabbit

One ought to carry away from a study of the rabbit two or three very important truths.

Nature's usual method of creating new and serviceable organs is to transform old ones. A simple tube, the oviduct, instead of merely transporting reproductive cells from the central and protected parts of the body to the outside, as with the fish and frogs, has become an abiding place for the young, where development may go on and the complicated nervous system and other organs have time to fully mature.

The reproduction of all animals, from fish to man, is carried out by means of very similar organs. Essentially these are: a gland to prepare special reproductive cells in which are placed the growth material, capable, when joined with its opposite, a male or female cell, of building an organism not only like the parents but resembling the species and, more remotely, all of the ancestors that have gone before; a pair of tubes which either pass the reproductive elements at once to the outside, or, as in the female of mammals, retain them during the process of development.

The means by which the united cells are enabled to grow into an organism varies only in two ways. The earlier way was to supply the egg with building material and to protect it from too great evaporation and injury by gelatinous or shell-like covering, trusting to the heat from some outer source to supply the energy needed for development; the other and later way was to retain the egg within the oviduct and to supply it from moment to moment with the material, moisture, and heat that is needed.

Finally, sex—maleness and femaleness—is nature's way of so dividing up the difficult work of reproduction that two organisms with their separate streams of heredity may accomplish it more easily and effectively than one. We do not mean to imply that this division of labor in producing young is the only meaning of bi-parental generation. There are other principles involved too technical and remote to the present interest for discussion here. The separate and complementary services of the male and the female in caring for the young from the moment of fertilization to that of their independence, remains the most obvious aspects of sex.

The special set of organs in the two sexes set apart to carry out the work of reproduction were originally the same, since they correspond part for part. In all of the higher forms, the sex cells show this division into sperm and egg cells, but there are animals in which the two kinds of reproductive apparatus are found in one body. The same is true of plants. Indeed, if we go back far enough in the plant and animal world the difference between sperms and eggs disappears, and there is left but the union of two similar cells as the first step in producing another life.

The question is often asked in what way the reproductive organs of man differ from those of the animal. Fundamentally there is no difference, but there are naturally many variations of detail, such as size and position of organs, number of young, length of the period of gestation, etc. Physically speaking, the relation of man to the higher animals, especially the apes, is affirmed in a thousand ways. Sexual reproduction is part and parcel of the vertebrate organization. It is so closely identified with the animal economy as to exhibit little change from the earliest times. Thus, the ovaries of most fish produce hundreds of thousands of eggs during the life of the fish. Likewise, each ovary of a three-year-old female child has fully 400,000 eggs within it. Since at most only a few hundred eggs are discharged, nature makes an effort to economize by reducing the great number to about 36,000 by the time the child is eight years of age. The sperms of the human male are produced by the hundred million. Though many are still needed, such vast numbers probably reflect a time when they were shed in the water and great numbers were required to insure fertilization of the eggs.

Human Sperm Cells and How They are Produced

There are several typical methods of reproduction in the living world: (1) that of direct division, as in many low orders of plants and animals in which a single cell, the parent, divides to form daughter cells; (2) that of spore formation, as in ferns and fungi; (3) that of budding, in which a single parent gives rise to progeny by pushing out a bud from the parent body, the new individual remaining in connection with the parent body or detaching itself; (4) that of bulb formation; (5) that of sexual generation, in which specialized cells are regularly set apart to perform the function of producing the new individual. Most plants and animals have come from ancestors that early chose this last method of reproduction. For all vertebrates this method is universally true. When

PLATE IX

The human embryo of about four months. The area of attachment to the mother's womb, the placenta, appears at the upper part of the figure; below and continuous with the placenta is the outer membrane covering the child. For the relation of the child to the uterus, see Figure 10, page 70.

the level of the mammals, including man, is reached, the sperm and egg cells are so small that they cannot be distinguished except by very high powers of the microscope. See Figures 4, page 56, and 5.

Sperm cells of animals were first seen in 1677 when the microscope was improved, but it was long before their true nature and purpose was understood. A sperm cell is characteristically an elongated body with a nucleus and a thread-like tail which it uses in swimming. (Figure 5.) They are usually found in a thick fluid much like the white of egg, called the semen or milt. Sperm cells are produced in special glands, the testicles, by the mother sperm cells. [They are called mother sperm cells though they are in the body of the male.] These line the inner surfaces of about eight hundred small tubules in the testis, each of which, when uncoiled, is fully two feet in length. This offers a very large surface for the mother sperm cells and we see how it is possible for them to produce so many sperm. As the sperm are produced, they are gathered into some twenty collecting tubes and pass on to the very much coiled epididymis and from this through the long vas deferens or spermatic duct, the shape and course of which were described in the rabbit. (Figure 6.) From the spermatic duct the sperms pass, when needed, through the ejaculatory duct (VII, Figure 6) to the urethral canal of the penis. *At the time of sexual union the sperms are deposited at the mouth of the uterus or very close to it.

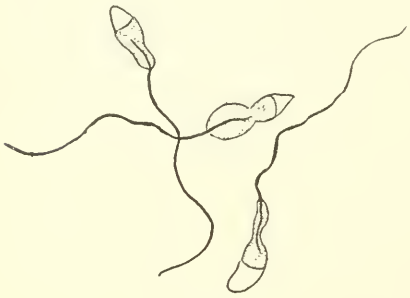


FIGURE 5

The exceedingly minute sperm cell of the human male has a long tail and a flat head within which is found a nucleus similar to that of the egg. They are found in vast numbers in the normal seminal fluid.

* It has been long believed by physiologists that sperm cells are stored in the seminal vesicles. (VI, Figure 6). Recent research, however, makes this conclusion somewhat doubtful, but further investigation will be necessary before the point is definitely determined.

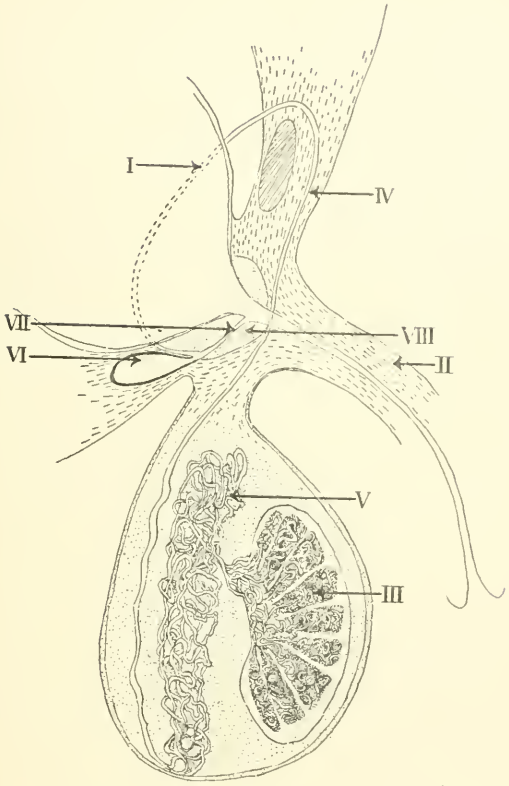


FIGURE 6

In this sectional diagram of the sex organs of the human male four principal structures will be noted: The bladder I, the penis II, the testis III, and the spermatic duct IV, connecting the testis with the penis.

The sperm cells of the male are produced in about 800 minute coiled tubules each of which is fully two feet in length. After being produced, the sperm cells are collected in larger tubes and are passed on to the long (20-foot) epididymis V, the much coiled beginning of the sperm duct. This structure lies close about the testis, but is separated here in order to show its relation to the testis. The epididymis is continued in the vas deferens or spermatic duct proper, IV. The spermatic duct passes in front of the pelvic bone, around the side of and below the bladder where it empties into the urethra or canal from the bladder. The seminal vesicle, VI. A short duct, VII, leads from the vesicle to the urethra or canal from the bladder. Glands, VIII, surround the urethra and duct.

The diagram is made through the right testis. The testis, duct and seminal vesicle are double or paired.

The Ova and their History

As the sperms are the smallest of all the cells of the body, so the ova are the largest. The ova of man and the mammals, however, may be seen by the naked eye when carefully isolated. While there are a great many more ova produced in the ovary (an oval body scarcely an inch in length) than are used, there are still larger numbers of sperm cells produced.

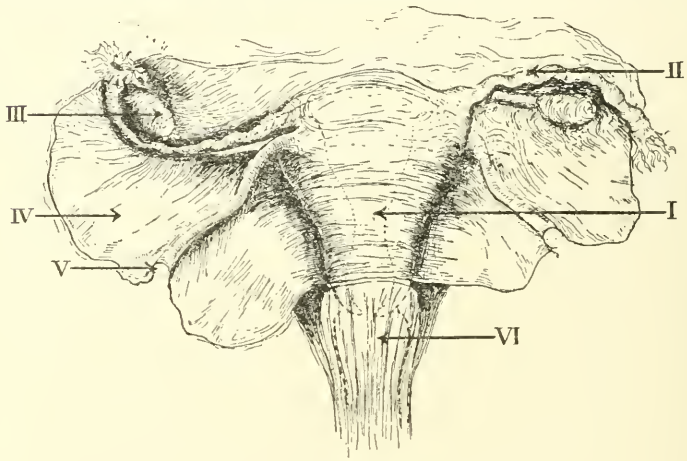


FIGURE 7

The reproductive organs of the human female include the uterus (womb) I, the egg-tubes II, and the ovaries III. The uterus is supported by broad IV, and round V, ligaments. For a sectional view of these organs showing their relation to the other organs of the pelvis, see Fig. 8, page 65.

The ripe egg discharged from the ovary is drawn into the egg-tube by the fine ciliated cells lining the tube and extending out on the finger-like processes at the tip of the tube. The egg passes on to the uterus where it lodges if it is fertilized.

The powerful muscle fibres of the uterus, in contrast to those of the vagina VI, is indicated. For the appearance of the uterus during gestation, see Fig. 10, page 70.

The sperm cells of the male are constantly being made during the lifetime, but the ova of the female are all produced before birth, and even, as we have seen, reduced in number after birth. A process of growth of each individual ovum goes on during the reproductive period in which a sheltering envelop, the follicle, forms about it. Yolk is accumulated and the nuclear material is reduced by half in preparation for the union with the nuclear material of the sperm cell. This

reduction of nuclear material is made so that when the union with the sperm cell (which has also been reduced) occurs there will be no absolute increase in this substance from generation to generation.

At intervals of about four weeks and associated in some way with the menstrual period of the female, an ovum,

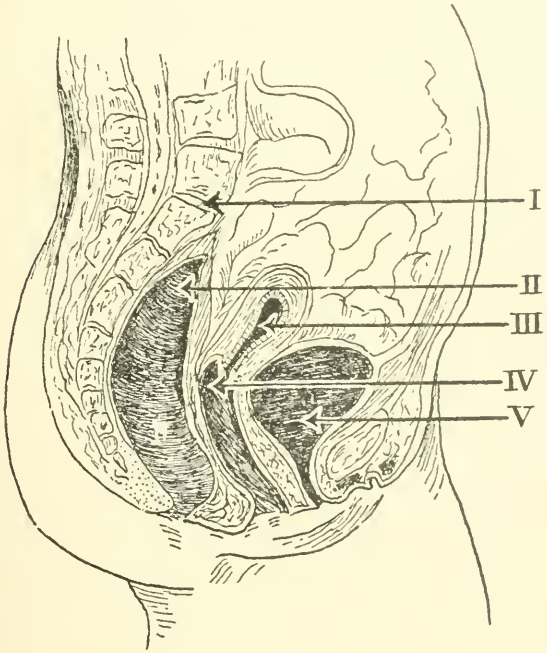
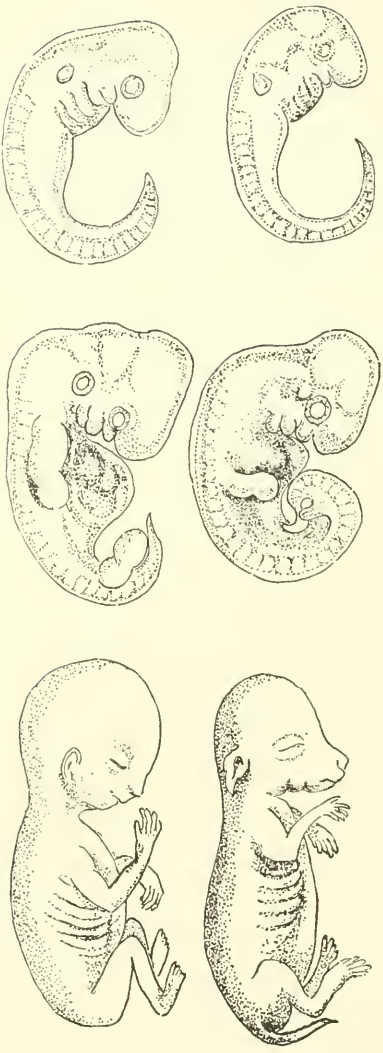


FIGURE 8

Four large structures are shown in this diagram of the human female pelvis, viewed from the side. The lower vertebræ of the spinal column I; the lower bowel (rectum) II; the uterus (womb) III; the vagina or vestibule leading to the outside IV; the bladder V.

sometimes one from each ovary, breaks through its follicle on the surface of the ovary and is drawn into the enlarged end of the oviduct or fallopian tube (Figure 7) by the currents set up by the many little ciliated, or whip-like cells which line the tube and its mouth. At any moment after entering the tube the ovum may encounter sperm cells which have made their way slowly through the uterus and up the



THE CHILD THE RABBIT

FIGURE 9

The striking similarity in the appearance of the growing embryos of man and the mammals is illustrated by comparing the human embryo of 21 days with the rabbit of a few days (first pair of embryos above). There is, further, no essential difference between the human embryo of 28 days and the rabbit of 7 or 8 days (second pair). After this time, however, the difference becomes marked and increases as the rabbit approaches birth at 30 days and the child at nine months (third pair). The child is of course larger at time of birth than the rabbit (after Haeckel).

tubes. The instant the first sperm cell gets through the outer zone of the egg a sheath or membrane is thrown about the surface of the egg which prevents other sperm cells from getting in. Occasionally, however, it is believed, two sperm get in. One way of accounting for twins that are physically united like the Siamese twins is to suppose that two sperm cells have divided the egg and the nuclear material between them. United bodies of this kind are called 'identical twins'. Twins are, of course, also produced by the fertilizing of two ova at the same time, such being known as 'fraternal twins'.

After the ovum has united with a sperm cell it is known as a fertilized cell, whose hereditary substance is derived from both parents. The fertilized cell of man and the mammals cannot be distinguished, and is very much like that

of the corals, sponges, and star-fish. Indeed the first steps in making the embryo, the multiplication of cells, the mulberry-like ball which results, the hollowing out of the ball, and the cupping in of one side as one would press in a hollow rubber ball, to make the alimentary canal or stomach, and the formation of the two resulting layers are the same for all creatures from sponges to man. Some idea of these early stages in the formation of animal bodies may be had by a study of the frog's development (Figure 2, page 36).

The relation of the fertilized ovum to its environment, on the other hand, sometimes floating in the water, now shell covered—or again nestling in the walls of the uterus, differs greatly. The protective envelops or membranes surrounding the growing embryo differ also in birds and mammals.

It is essential to remember that human life, in common with animal life, starts from a single fertilized egg or stem cell. Biologically, this means, when taken in connection with evidence from many other sources, that the sex cells were once independent, free-swimming beings—all of life that then existed—and later, when they gave rise to many celled bodies, they retained the power of reproducing themselves and their bodies. Through them, it naturally follows, all inheritance is transmitted, rather than directly from body to body. It is interesting to know that sex cells, those that go to make the ovaries and the testes of the new individual, are set aside soon after the first cell divisions begin, which indicates how closely these cells are linked together as they pass from generation to generation of the bodies which they build.

Growth of the Human Embryo Compared with that of the Rabbit

We have seen that the fertilized ovum, the first cup-shaped (gastrula) structure, and the two primitive layers of cells (a third layer is introduced between the other two in embryos of animals above sponges) are the same for all animals. With the advance to the higher back-boned forms the resemblance continues, as the digestive and excretory (the kidneys and the reproductive organs are included here) tracts are elabo-

rated, with increasing divergences in different animals in the case of the vascular, respiratory, muscular, and nervous systems.

It is, in fact, a law of the development of organisms that the peculiarities which distinguish groups of animals—those, for example, that separate the rabbit from man—only appear gradually. The closer the resemblance or relationship, the later these differences appear.

Compare, for the illustration of this law, the appearance of the human embryo of twenty-one days with that of the rabbit only a few days old. (Figure 9.) Their sizes are practically the same, being about two-tenths of an inch long. Both show the gill clefts, which are expressions of nature's inability to forget that man and all the vertebrates were once fish; the two higher sense organs, the eye and the ear, are marked out, but there is no trace of limbs.

By the twenty-eighth day the human embryo is almost half an inch long, and the rabbit within two days of birth. Comparing, however, similar stages, there is little difference between them. The head and its various parts are clearly marked out, and the rudiments of the eye, ear and limbs are seen. The head bends almost at right angles to the body. The tail of the human embryo is twice as long as the legs. Inside of the body, all of the principal organs are outlined. There are still no essential features that set man off from the dog, rabbit, or horse, although the various embryos may be distinguished by different proportions of the body parts.

Beginning with the eighth week of the human embryo, there are important differences of the size and shape of the head that clearly set man apart from the mammals. The correspondence which has been noted between man and the mammals continues, now, with the higher apes, the gorilla, and especially the chimpanzee. Not until the seventh or eighth month can the fœtuses, as they are now called, of man and the apes be told apart. After passing the plane of the apes, the child enters the heritage of the human races, and it is not until sometime in the ninth month that the racial features are distinguished. Family resemblances

follow, some aspects of which, indeed, do not become apparent until maturity.

Birth

The outer surface of the egg, immediately after fertilization, throws out processes which enter the walls of the uterus much as though it were a parasite. As soon as this is done the surface of the egg grows rapidly, so that it becomes an envelop about the embryo which occupies, at the outset, but a relatively small space in the interior. The embryo is attached to the inner wall of the now very much expanded egg by means of a stalk, through which the blood courses to and from the mother as soon as the yolk with which the embryo is supplied is used. The stalk then becomes the navel, or umbilical cord. The villi, or processes which have entered the uterus, withdraw from all portions of the envelop except in the neighborhood of the stalk attachment of the embryo. (Plate IX.) Here they enter more deeply into the uterus and make a circular disk of soft, spongy texture, six or eight inches in diameter and perhaps an inch thick, known as the placenta.

There is no direct connection between the blood of the mother and that of the growing child. The nutritive serum from the mother is deposited in the placental region of the uterus and there absorbed by the many terminal blood vessels leading through the umbilical cord to the placenta. All of the higher animals have placentas, those of the higher apes and man being almost identical, but the mammals showing different sizes and shapes.

As the time for birth approaches, the child takes up a position with its head toward the outlet. The muscular walls of the uterus have thickened and grown. By rhythmic contraction, sometimes long continued, the head of the child is forced through the two envelops which have sheltered it through nine long months, at the same time freeing the fluid within the inner one. The pelvic bones are stretched apart and the child makes its way through the vaginal canal to the outside. It brings with it the cord of blood vessels, which

the attendant severs close to the body of the child. The animal mother instinctively cuts this cord with her teeth. The placenta, together with parts of the uterus wall which,

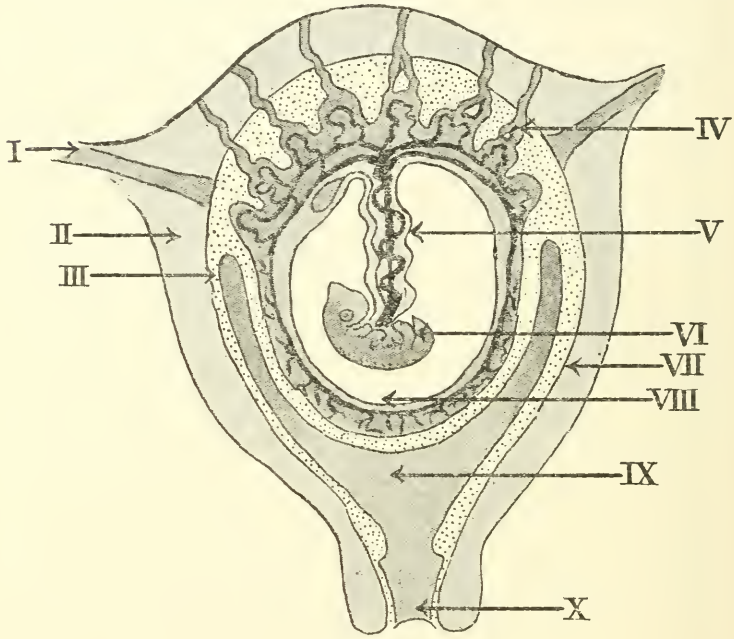


FIGURE 10

The relation of the human embryo to the uterus of the mother is shown in the diagram. The two oviducts or egg-tubes I, lead into the uterus. The uterus, during the time the child is being carried, may be divided into two main portions: the solid muscular wall II, and a spongy interior lining III. The blood vessels from the mother IV, penetrate the lining, enabling the circulation V, from the embryo VI, to obtain nourishment from the mother and to transfer to her waste materials. The embryo itself, VI, floats, at this stage in a liquid within a cavity VIII. In reality there is no open space as represented at IX, the membrane covering the embryo pressing close upon the walls of the uterus. At birth the mouth of the uterus X, is greatly expanded to permit the passage of the child.
After the birth of the child the two portions of the uterus mentioned above divide along the line indicated by VII, and the inside portion passes out of the uterus as the afterbirth.

thus united, form a solid mass, soon passes out after the birth of the child. (Figure 10.)

Birth is a difficult thing for both mother and child. Mammal and human embryos grow in a fluid which gives them no opportunity to practice breathing and probably little in

swallowing. They are thus called upon suddenly at birth to assume functions that have never before been tried. The heart, the muscular and nervous systems have long been active. With the prepared food of the mother, digestion does not seem difficult.

The Two Factors that Separate Man from the Animals

We have referred repeatedly to the very close parallel in the development of man and the mammals, and, at earlier stages, of a similar parallel between the mammals and the simpler animals. The purpose in doing so is not only to state the facts, but to simplify, as far as possible, the task of understanding the nature of animal and human development.

There is, however, a great difference between man and the mammals. For most people, the differences far outweight the similarities. From the viewpoint of physical development this cannot be true, but there are two factors intimately related to man's sexual life which are decisive advances upon anything found in the animal world.

The first and most important of these is the lengthened period of human infancy—a period measured before, as well as after, birth. Although there have been greatly different rates of growth, there is, at the moment of birth, little difference between the young of man, the mammals, and many birds as far as helplessness is concerned. In a matter of a few weeks, however, the mammal—the rabbit, for example, is able to care for itself. For the child it is a question of years, due to both its slow development, and, in the case of the child born in civilization, to a complex and difficult environment. The prolongation of infancy is unique for the human species, for although the elephant, the slowest breeder among animals, has fewer offspring than man and carries the young longer in utero, there is a relatively shorter growth period for the young after birth. This lengthened period of infancy and early childhood has had much to do with the development of family and communal life.[1] Probably family life has in turn lengthened the period of development.

[1] Cf. John Fiske. Cosmic Philosophy, Vol. II, p. 344 et seq.

A second factor is the existence of self-conscious thought in human beings and the play of this thought upon the reproductive instincts. Further reference to this factor will be made in the next chapter. It is sufficient here to recall that thought, including, of course, memory, has the power of greatly modifying the instinctive sex behavior of man. This may take the direction of sexual degeneration or perversion, on the one hand, or of restraint and of a reduced birth rate on the other. The conflict of thought and instinct operating under the conditions of civilization, introduces the most serious problems in human life.

NATURE STUDY AND THE PERSONAL PROBLEMS OF LIFE

Up to the time of adolescence or puberty the child lives in but one world and that is an outer or objective one. The self is forming, but it is not set off sharply in contrast with the outer world and the interests of others. While there are desires demanding gratification, these are not really problems. The mind goes eagerly outward in search of experience, information, and adventure. It is the time when the greatest possible number of objects are got together in collections; when curiosity is aroused and welcomes information about the plants and animals; when the habits, behavior, and devices by which plants and animals maintain and propagate themselves are of enthralling interest. It is the time when nature study means most. In these years the child should become familiar with the way in which reproduction is accomplished in the plants and in the animals. This information will be quickly assimilated if it is available, unless, indeed, the curiosity about the ways of natural things is dulled by the lack of interest on the part of parents and teacher.

The Coming of Puberty

The coming of puberty and the attendant adolescent changes bring real problems to the life of the growing self. The mind is no longer disinterestedly looking outward. There is the coming, the birth, of a real person within. Nature is only seen with half an eye now, so to speak; the other half being occupied with the events and emotions going on within. Interest no longer ranges freely, but is confined, in most youth, to those objects which subserve some personal end, or means thereto. Things begin to have meaning, not abstractly and for themselves, but for the self. Sex in nature is no longer merely one of the activities of life, but it is something that has a personal bearing and meaning, something that may illumine the dark passages within. It were well, perhaps, if

youth continued to look upon nature singly, with the eye of the child; it were well, perhaps, if there existed for him but one world instead of two, so that when the stage of reflection and full self-consciousness is reached, the youth might still see the self as a closely membered form of the natural creation. This power may come again with the years, it may be the continuing possession of gifted minds, but for most of us, it passes with adolescence.

Yet even here there are compensations. Strange passions and appetites are awakening. An intense, one might even say, an intelligent selfishness, prepares the way for lust as the great and unregulated forces of creation come to birth in the boy. But along with lust comes chivalry. Man seems to have inherited the impulses or instincts that make the higher life possible. A devotion to ideals, a capacity for sacrifice, and, for the moment, a power to enter into high social ideals, struggle side by side with impulses which lead directly and without circumlocution to reproduction. It makes a tremendous difference to youth which of these two sets of forces receive reinforcement from the environment. Sexual impulses may be turned into depraved and vicious acts, or they may be controlled, adjusted to social life, and made the agents of personal and racial good. There are those whose heredity or early environment commit them without a struggle to the worst; there are, on the other hand, those whose environment is fortunate, whose physical and mental development goes on uninterruptedly, and who have the rare privilege of entering upon marriage with all of its obligations and steadying influences at the time when these are most needed. For the great majority of youth, however, there are many dangers and many problems of life to be settled and adjusted.

What May Nature Study Do

There is no intention to maintain here that nature study, even though it deal with the entire life history of living creatures rather than conventionally acceptable portions of them, will of itself solve the problems of youth, or indeed, greatly lessen the strain of the 'storm and stress' period. It

is asserted, however, that such information will be of service especially when given early, and by those who can make it a part of the wisdom of life. In fact, nature study, thus understood, is only another cultural influence, a means such as all culture offers of looking upon life broadly and humanely. There is nothing that can be offered youth, not even religion itself, which carries with it a guarantee of safety and security. On the whole we are gaining more confidence in methods of intelligent preparedness to meet the issues of life than in moral suasion alone. Example is good, but how seldom it is at hand at the right hour, and how rarely it fits the particular crisis!

The success with which nature study is used in sex education will be proportionate to our information and the richness and fullness of our own interpretative power. Mere facts, of themselves, will not go far, but when to them is added the sympathetic and seeing eye, much may be accomplished. We shall, for example, no longer think of sex or reproduction as degraded, debased, or alien to our humanity. That sex does become so and that it is the root of so much misery does not alter the fact that, as far as the natural creation is concerned, sex and all of its associated structures and activities are wholly good and have been mainly instrumental in giving rise to those things we prize most highly in life. Our dignity, our sovereignty, though they exist only potentially, are affirmed by the fact that we may become more blinded with passion than the animals can ever be. Nature study will show us that our problem is a dual one. There is, first, the action of the instinctive forces of reproduction which are in unavoidable conflict with the restraints of civilization, with monogamous marriage and with the long and involved preparation for marriage. Then, second, the human intelligence, which, seeing the instincts thwarted and opposed by social requirements, joins in with the instincts to gain satisfaction by deceit, subterfuge, and the sacrifice of others.

The Best Course to Pursue

The best preparation that can be made to meet the inevitable crises in the life of youth, we reaffirm, is not to avoid the

issues, not to trust to the exemptions of innocence, not to feel that somehow the young person will stumble through as others have, but to take the full measure of the situation. Equip the contestant with a full knowledge of the enemy. The conflict, however, is not to resolve itself into one of Puritan against Satan, but rather into one of disciplining and turning to useful service a power that, unregulated, may wreck life.

The Girl, as well as the Boy, Should Understand the Biological Meaning of Sex

The male, as we have had occasion to see, has by slow process of selection, assumed the active part in propagation. This fact makes the problem of the boy much more difficult of solution than that of the girl. The disproportion in the intensity of the impulse in the boy and the girl should not, however, be taken to mean that the girl is less in need of enlightenment and preparation. On the contrary, her ignorance of the manner in which sex expresses itself in the man as contrasted with the woman, is responsible, both before and after marriage, for much of the disharmony, disillusionment, perhaps pain and misery of life. After marriage very serious adjustments and adaptations of two highly different natures, remain to be made, not once but constantly. It is a time when sympathy, even love itself, is not enough. With these qualities must go good insight and an understanding of the meaning and purpose of sex.

The Justification for Sex Education

The revelations of the inner life of the soul in the modern psychological laboratory show how great has been the havoc of mind caused by the inability of the growing person to bring about an equilibrium between the torrent of impulse within and the many outward barriers which civilization has raised against what it considers improper expressions of sex. The youth of savages and of the native races experience no such crisis, since the racial welfare usually demands all of the procreative resources of these people. But modern

civilization would be impossible with a free play of sexual impulse, realizing itself in temporary and promiscuous union, in degeneracy, and in the wide spread of social diseases which follow. Society exists because a sufficient number of people live clean and strong lives. Our customs are therefore basically right in suppressing and penalizing these racially disadvantageous, for such they are, expressions of sex. Social regulations are usually blind and irrational in their modes of operation, if not in their intentions. They are lamentably weak and their failure to control is expressed by the existence of such classes of men and women as those who are openly depraved and defiant of the moral order; those who secretly, and to them, profitably, desecrate the ethical ideals of the race; and those who, in conforming to the moral mandates of society, do so at such cost to themselves in inner suffering that mental derangements frequently follow.

We must say again, in conclusion, as we have said before, the mitigation of the miseries and wastes of human life that arise from the misuse and misdirection of sex does not lie in continuing ignorance of the facts of life, or in more arbitrary suppression of the natural tendencies in youth. It equally does not lie in granting more license to the individual in realizing his sexual desires; nor does it lie in merely acquiring biological facts.

If there is any justification for sex education it must be because it offers definite help in solving the intimate problems of life as far as sex is concerned. The broader sex education proposes to enlist the coöperation of youth's own intelligence. It opens for him the vistas of nature and discovers to him the vital and necessary place that sex has occupied in the living world, thus aiding in the translation of a personal interest, liable to perversion, into the appreciation of a universal and pivotal principle of creation. New avenues for the employment of the energies of body and mind are to be provided in order that the outward-going forces may not be turned back upon themselves. Though parents and teachers do their best, the hour of trial will come, and, if circumstances are adverse, it will come repeatedly; it is now that a victory over the sub-

human impulses of sex is a victory for both self and civilization. It will be shown to youth that a clean, upreaching and outspreading life is good in and of itself and carries its own reward; that there is, indeed, an inner and sufficient reason for what the race calls morality.

A cold and impersonal policy of silence or of intolerance supplies none of these aids; and the problem is too difficult for many youths to solve unaided. Our help must be human and individual; not in the old way, by crude, mass action, merciless, torturing both the guilty and the innocent alike, gaining here and losing there. Rather it should be as parent to child, teacher to pupil, physician to his patient, prophet to his people.

SUGGESTIONS ABOUT BOOKS

THIS BOOK is but an introduction to sex education; moreover it barely touches the field of nature study. As the reader follows his interest further in this field he will desire, probably, to consult more comprehensive books. There is an abundant nature literature which is readily available. With regard to sex education, a number of excellent books have been published and others will no doubt appear from time to time. Owing to the fact that there are so many aspects of the subject, each adapted to special needs and purposes, it has been deemed advisable not to recommend here a general list of books. An inquiry of this nature, however, addressed to The American Social Hygiene Association, 105 West 40th Street, New York City, will receive in answer a selected list of books, suited, as far as possible, to the needs of the inquirer.

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